176.

FEBRUARY 4, 1981

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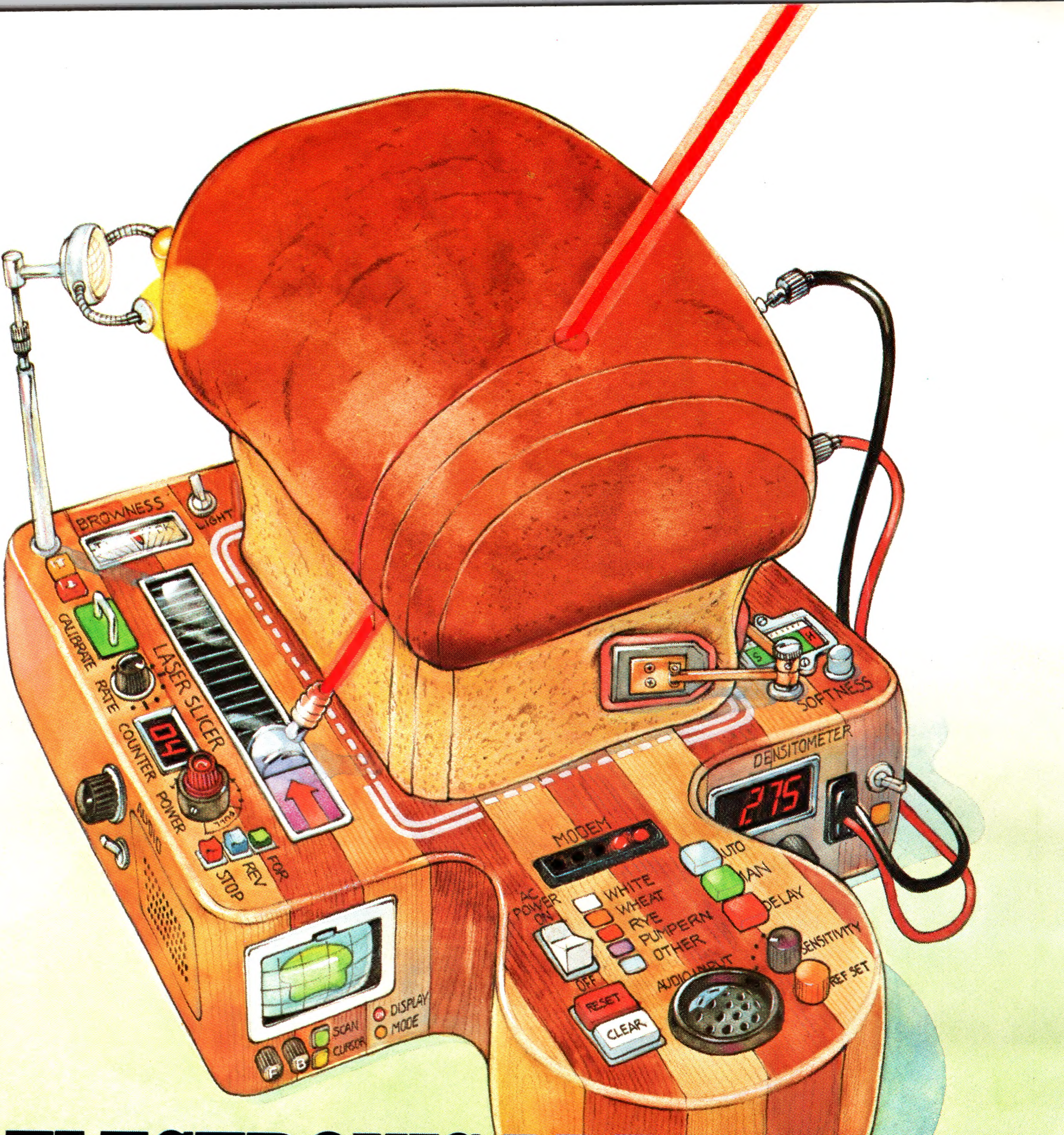
Switching-supply stars blaze to new performance highs



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For Resistor Selection Guide circle ***80***

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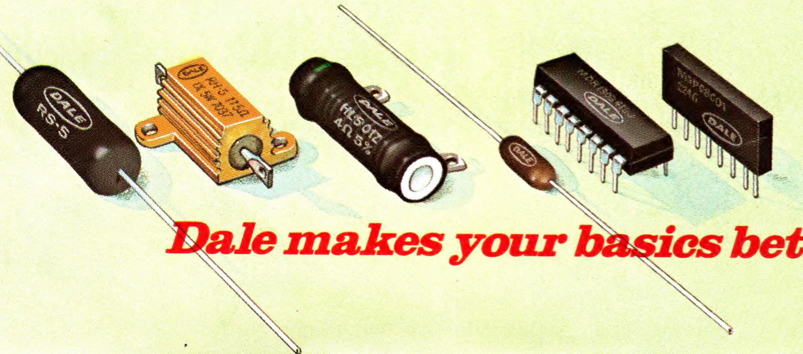

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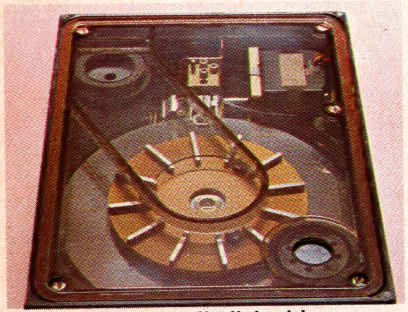
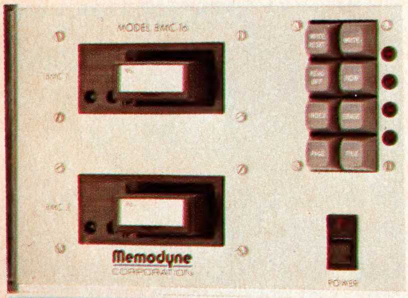
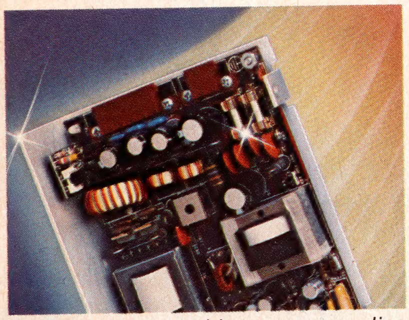


Advances in small disk drives *pose tough decisions for system designers (pg 45).*



Bubbles sub for tape *in 128k-bit data logger (pg 81).*



On the cover: *Switching power supplies are rocketing into new applications, thanks to several technical advances. Turn to pg 94 for the details. (Photo courtesy Power/Mate Corp)*

DESIGN FEATURES

TECHNOLOGY NEWS

NEW PRODUCTS

DEPARTMENTS

CP BPA ABP

EDN (ISSN 0012-7515) is published biweekly (except monthly in July and December) by Cahners Publishing Company, Division of Reed Holdings, Inc, 221 Columbus Avenue, Boston, MA 02116. Norman L Cahners, Chairman; Saul Goldweitz, President; William M Platt, President, Boston Division. Controlled Circulation paid at Pontiac, IL 61764 and Oakland, CA 94623. Postmaster: Send Form 3579 to EDN, 270 St Paul St, Denver, CO 80206. Advertising and editorial offices: 221 Columbus Ave, Boston, MA 02116. Phone (617) 536-7780. $2/copy (special issues may vary), $30/year; international subscriptions: $5/copy ($3/copy in Canada) (special issues may vary), $70/year ($40/year in Canada), with air mail delivery available for $150. Send requests for qualification forms and/or change of address to subscription office.

Powerful HP Series 9800 deskto
acquisition and control: the tim

Imagine a computer with the interfacing power to automate your test and measurement system in days, instead of weeks or months. A computer that puts the entire system under your personal control—even if you're not a programmer.

Imagine how much more productive you could be with an HP Series 9800 computer.

A balance of power.

If you've been thinking that a desktop computer just isn't powerful enough for data acquisition and instrument control, think about this:

Today's Series 9800 desktop systems let you send completely formatted data at rates up to 16K bytes per second and handle up to fourteen channels of vectored interrupt (with high and low priorities). Direct Memory Access (DMA) permits capture of real-time data from high-speed devices at up to 800K bytes per second. And, with user-addressable memories ranging from 62K to 449K bytes, built-in magnetic tape drives, optional I/O ROMs and a wide variety of peripherals to choose from, the Series 9800 delivers big system power you'd never have thought possible in such compact and conveniently integrated packages.

Pick a card. Any card.

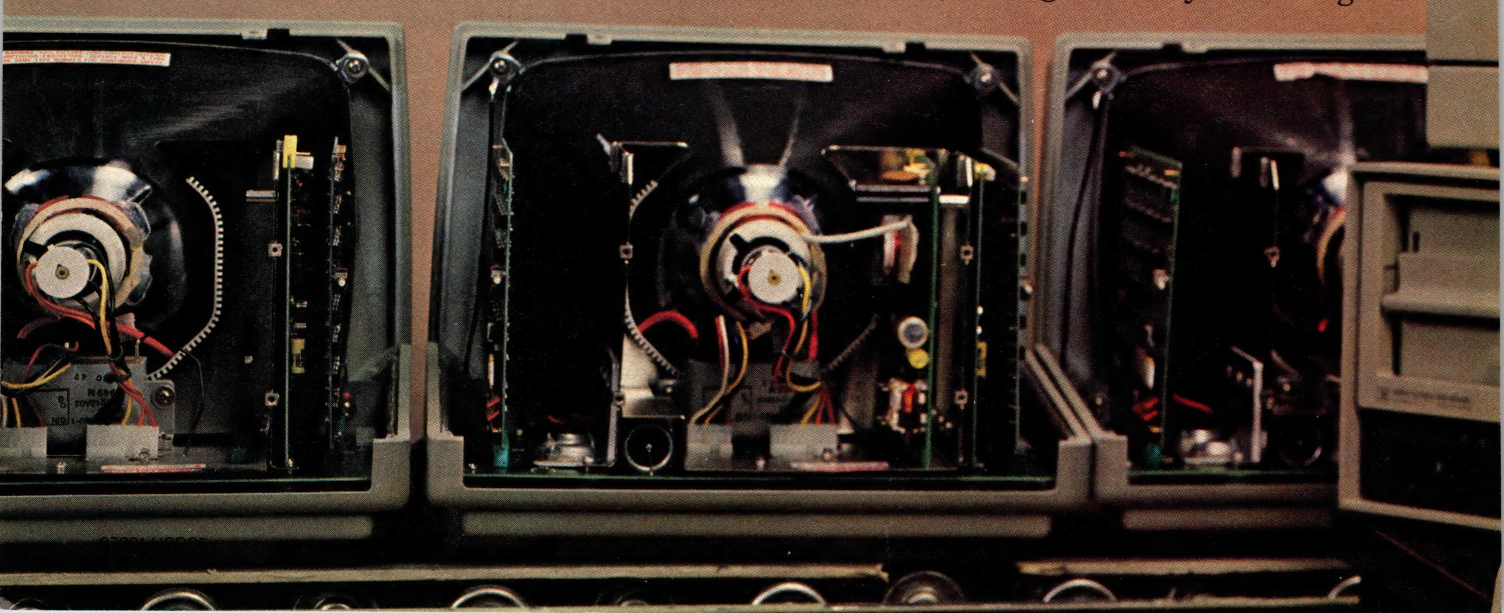
Interfacing to your instruments and any combination of HP printers, plotters, and storage devices has never been so easy. Just choose the plug-in interface card that's right for your needs: HP-IB, Bit-Parallel, BCD or RS-232-C. The I/O drivers are already built-in, so you can concentrate on your applications, and not on system configurations. The result? Less development time (which means a lower total cost), and a more productive system all around.

Plenty of room for growth.

The Series 9800 represents a wide range of desktop computers, so you can start building the system that makes sense for your jobs.

Our high-speed HP 9825, for example, is ideal for interactive device control. The System 35 gives you the option of an alphanumeric CRT and Assembly-language programming. The System 45 offers advanced graphics. And our new HP 85 personal computer provides an excellent balance between power and price for low-cost automation.

What's more, if your applications warrant it, you can get an added dimension of versatility by linking your desktop computer to our powerful HP 1000 minicomputer system. Communication is easily managed, and by combining the



Books

Advice on protecting your innovations

Patent It Yourself! *by David Pressman. 210 pgs; $15.95; McGraw-Hill Inc, New York, 1979.*

A detailed guide for the inventor, this book offers advice on developing, protecting, patenting and marketing ideas. The author draws on his experience as an electrical engineer and patent attorney in reviewing the legal and commercial pitfalls that the do-it-yourselfer must avoid.

For example, he emphasizes the importance of keeping accurate records that confirm the identity of an innovation's inventor. And he shows how to maintain and witness lab notes. A collection of sample forms at the end of the book—including those used for filing disclosures, applying for a patent, providing a statement of prior art and requesting a certificate of correction—could facilitate correspondence with the Patent and Trademark Office.

This manual overflows with detailed specifications—guidance on treatment of large or formal sketches, photos and graphs; making an effective sales presentation; determining an invention's market value; and publicizing a new product. Limiting his use of legalese, Pressman suggests where to look for professional help, recognizing that not all inventors can or want to represent themselves, but that most *do* want to understand the legal process.

A bibliography and checklist of important steps for the inventor conclude this thorough lesson in patent protection.

— ***Ann Rogers***

A new idea in low-cost instrument automation.

Simplicity.

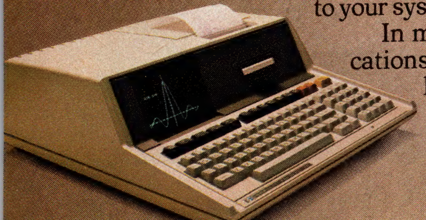
It's the HP 9915 Modular Computer—the first in a new generation of easy-to-use, low-cost computers for measurement automation.

The HP 9915 is priced like a board computer, but the comparison ends there. It's a powerful desktop computer, the HP-85, in a modular, rack-mountable package. We left off the keyboard and CRT to give *you* the flexibility to design just the operator interface you need.

The 9915 has the same operating system, I/O drivers, language support and ease of programming as the 85, so building your systems will be a lot simpler, and take only a fraction of the time. You'll save a bundle on development costs.

Designed for designers.

With the HP-85 as a 9915 emulator, program development couldn't be easier. Simply write and debug your application programs in BASIC, then transfer your software to the 9915 via EPROM or tape cartridge. Connect the 9915 to your system and you're ready to go.



In many measurement applications, all the operator needs to know about running the system is right there on the 9915's simplified front panel. But if the job calls for a custom keyboard, or remote display, it's simple for you to connect them. No matter what the application, you pay only for the capabilities you need.

Plug-in power.

With the same flexible I/O features as the 85 (including interrupt, high-speed transfer and easy data formatting), the 9915 gets you halfway to your solution before you even start. The I/O drivers are built-in, and because the 9915 uses the same plug-in cards as the HP-85—HP-IB, RS-232-C, Bit-Parallel and BCD—interfacing to your instruments is a snap.

The 9915's 16K byte user-addressable RAM can be expanded to 32K with an optional plug-in memory module. And in addition to the available user memory, the powerful operating system (contained in 48K bytes ROM) can be expanded by adding optional ROMs for matrix math, plotter/printer control and mass storage control.

For more on the HP 9915, including OEM discounts, call your HP sales office. Or write for our new OEM catalog on computer solutions to Hewlett-Packard, Attn: Jim Geer, Dept. 2090, 3404 E. Harmony Rd., Ft. Collins, CO 80525.

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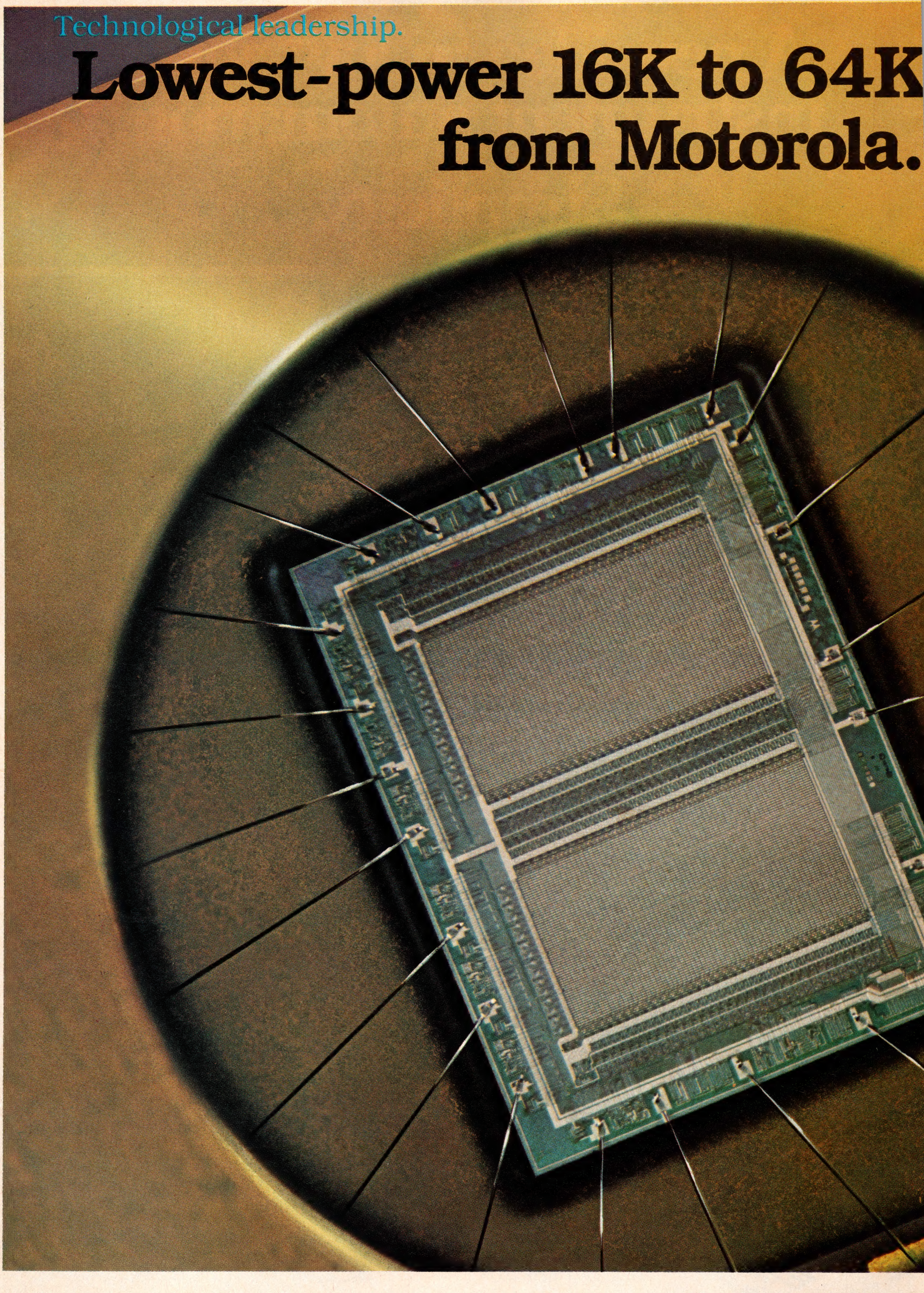
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5 V EPROMs Immediately available.

You'll find the ultra low-power 5 V EPROMs you're looking for in Motorola's comprehensive, quality-built 16K to 64K EPROM family.

That includes the MCM68764 and MCM68L764, far and away the lowest-power 5 V 64Ks available. The family also includes our MCM68766 and MCM68766-35 for those who need a 5V 64K with an extra-fast output-enable access time.

They're all available in volume from Motorola now.

These Motorola 5 V EPROMs are pin-compatible with the 8K through 64K industry-standard mask-programmable ROMs, right down to using the same 24-pin packaging. Even the 64Ks are "plug-in" replacements for the 24-pin industry-standard ROMs, as well as for smaller 5 V EPROMs. The 16K, 32K, and 64K EPROMs from Motorola all have JEDEC-approved standard pinouts.

Added attractions such as on-chip overvoltage protection circuitry help put these 5 V EPROMs in a class by themselves. The higher-performance versions are all ±10% supply devices.

Data retention in these EPROMs is superior, consistent with the high quality of product Motorola has been noted for since the 1950s. By superior data retention, we're talking about a failure rate of only 0.001% per 1000 hours.

The MCM68766 EPROM offers all the features and performance of Motorola's original ultra low-power 64Ks except power down. It has the same access time from address and an even faster 150 ns maximum output enable access time.

Order Motorola 5 V EPROMs now from your local Motorola sales office or authorized distributor. For additional information, use the coupon or write to Motorola Semiconductor Products Inc., Technical Information Center, P.O. Box 20912, Phoenix, AZ 85036.

Motorola's Comprehensive 5 V EPROM Family

Motorola Part Number	Access Time – ns	Max Active Current – mA	Max Standby Current – mA	5 V Supply Tolerance – %
16K EPROMs				
MCM2716	450	100	25	± 5
MCM27L16*	450	50	10	± 5
MCM2716-35	350	100	25	±10
MCM27L16-35*	350	50	10	±10
32K EPROMs				
MCM2532	450	100	25	± 5
MCM25L32*	450	50	10	± 5
MCM2532-35*	350	100	25	±10
MCM25L32-35*	350	50	10	±10
64K EPROMs				
MCM68764*	450	120	25	± 5
MCM68L764*	450	60	15	± 5
MCM68766	450(150[1])	160	–	± 5
MCM68766-35	350(150[1])	160	–	±10

*Lowest power in the industry [1]Access time from output enable

Industry-standard ROMs, 64K dynamic RAMs, fast static RAMs, and these leading 5 V EPROMs all point to one thing. Motorola has the MOS memories you need for

Innovative systems through silicon.

MOTOROLA INC.

TO: Motorola Semiconductor Products Inc., P.O. Box 20912, Phoenix, AZ 85036.

Please send me information on 5 V EPROMs

80 EDN 2/4/81

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Company ____________

Address ____________

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News Breaks

16-BIT-μP FAMILY SEES FIRST SILICON, GETS SECOND SOURCE

First wafers of the NS16032 16-bit μP came off the line at National Semiconductor's Salt Lake City plant in mid-December and are now undergoing evaluation and debugging. The complex 84,000-mil² die is the first of the NS16000 family of CPU and peripherals, which will stretch from a minimal low-cost system to a 16M-byte powerhouse that features mainframe-computer processing power.

At the same time, National announced an agreement with Fairchild Semiconductor (Mt View, CA) to second source the NS16000 family. The nonexclusive agreement covers only masks and design rules, with each company using its own proprietary, but compatible, HMOS process: XMOS for National and probably Isoplanar-H for Fairchild. National's part of the exchange involves the NS16032 CPU and systems-oriented devices; Fairchild will cover the dedicated-peripheral circuits. Both firms will develop a joint program to design future 16000 products.

A source at National says Fairchild was chosen for its strong manufacturing capability and parent company Schlumberger's known commitment to R&D. The agreement, however, does not preclude National's picking up another US source. The company is also planning on another European source in addition to Eurotechnique and several in Japan.

National expects that samples of the 16032 might be ready in May or June.—WT

1-PPM/°C VOLTAGE REFERENCES NEED NO STABILIZING OVEN

Guaranteed to spec ±1-mV initial accuracy and ±1-ppm/°C drift over 0 to 70°C, two hybrid voltage references from Analog Devices Inc (Norwood, MA) offer the best performance available without oven-temperature regulation, according to the firm.

Model 2710LD outputs +10.000V, while the dual-output 2712LD delivers ±10.000V. Both devices come in 14-pin DIPs, supply 10 mA min and feature long-term stability of 25 ppm/month. In 100s, the 2710 and 2712 cost less than $43 and $52, respectively. The firm also offers lower cost, ±2-ppm/°C J versions.—WP

TEST SYSTEM HANDLES IN-CIRCUIT AND FUNCTIONAL TESTING

The latest extension to Fairchild Test Systems' Series 70 board testers accommodates both in-circuit and functional pc-board testing. With the Billerica, MA-based Technical Center's $141,000 Model 60, you can use one bed-of-nails fixture to perform in-circuit tests or to access a card edge for functional checks. The Thinline fixtures used in this system are also employed on in-circuit testers from Fairchild's Subassembly Test Systems Div (Latham, NY). Model 60 can handle 512 test points and is expandable to 1920. Functional testing can run at clock rates to 5 MHz.—AS

PRINTER COMES IN EIGHT USER-SELECTABLE CHARACTER SETS

A low-cost addition to the Omni 800 Series telecommunications printers, the dot-matrix Model 840 from Texas Instruments (Houston) is available in eight user-selectable character sets. These sets include alphabets for the US (ASCII), France, the United Kingdom, Germany, Sweden, Denmark/Norway, Spain and Finland. The printer comes in either a KSR or RO configuration and prints 75 cps; TI plans to introduce it next month. Expect basic-unit prices of $1300 or less.—CW

SPEAKING OF VOICE I/O . . .

At the Consumer Electronics Show in Las Vegas last month, Interstate Electronics Corp (Anaheim, CA) introduced three voice-technology chip sets, marking the firm's first venture in the consumer market. Model 2A chip set provides 95% recognition accuracy for 24 phrases.

Model 2B is a custom version of the 2A. Model 3 furnishes speaker-independent recognition of four to eight words (85% accuracy) plus voice response. All sets are available only in minimum orders of 100,000 units.

. . . A package of software and two pc cards converts an Intellec development system into a workstation for designing voice-response and isolated-word- and phrase-recognition systems. The Voice Experimenter's Workstation from Technology Service Corp (TSC) (Santa Monica, CA) incorporates Interstate Electronics' Voice Recognition Module and TSC's Voice Control Unit, providing low-cost speaker-independent recognition. The Workstation without the Intellec system costs $7500.—ET

LEARN HOW TO MANAGE ENGINEERING PROFESSIONALS

Two seminars will examine how technical/personnel managers can develop the skills needed to deal effectively with subordinates.

One seminar, sponsored by the Boston College School of Management, will be held February 19 to 20 at BC's Putnam Center in Newton, MA. The course fee is $395. Call (617) 969-4217 for further information.

The other forum, scheduled for February 25 to 26, will be sponsored by the California Institute of Technology and held at the Newport Beach, CA Marriott Hotel. Fee for sponsors is $445; $495 for others. Phone (213) 795-6811 or (714) 750-7084 (ext 1041) for details.—AR

HARDWARE/SOFTWARE PACKAGE EXPANDS UNIBUS MEMORY ADDRESSING

If you use a DEC PDP-11 computer and want to address more than 248k bytes of main memory, you need not upgrade your CPU to a Series 44 or 70. As an alternative, Periphonics Corp (Bohemia, NY) offers its $15,000 Peripacs system, which maintains the standard Unibus structure whle permitting an essentially unlimited address space. It uses an active backplane to produce a multivalued map of Unibus addesses to memory.

The software supporting Peripacs, developed by Programming Concepts Inc (Coram, NY), replaces the RSX LOADR program on the DEC-supplied RSM-11M operating systems.—WP

200W SWITCHER PASSES VDE TESTS

Model XL200-3501 from Boschert Inc (Sunnyvale, CA) is the only open-frame 200W switcher with VDE 0730 safety-spec approval, according the firm's product-development manager, Jack Tuite. He adds that this approval virtually assures compliance with VDE's planned 0806 spec, expected to replace both 0730 (now aimed at office equipment) and the less stringent 0804 (now covering computer-room equipment accessible primarily to technically skilled personnel). The switcher is also designed to meet VDE 0871 (N-12) and proposed FCC EMI regulations.

The $385 supply furnishes 5V at 5 to 25A (with ±1% combined source and load regulation) and −5, −12 and +12V at 0.5 to 4A (with ±9% combined regulation). Noise and ripple spec at ±2% on all outputs. The supply operates on jumper-selectable 95 to 130V or 190 to 265V (47 to 440 Hz) inputs.

For more information on the latest switchers, turn to pg 94.—RN

VERSATILE PRINTER REPORTS MEASUREMENT RESULTS

Model 820 thermal printer from Newport Electronics (Santa Ana, CA) employs a Texas Instruments ceramic-substrate thermal head that creates 5×7 matrix characters in 20 columns. The $543 (1000) printer accepts parallel or serial inputs and sports a time-of-day clock and a print-interval timer that allows you to select one of 16 intervals. The 820 uses a Rockwell 6500/1 μP and includes 45 special measurement-related characters. Set for introduction next month, it suits panel mounting.—CW

Our new Multibus™ memory boards are unforgettable. If the power fails, they won't.

If you've got Multibus applications that demand retaining critical data, then NEC has two solutions to your problem. Because we've just introduced two Multibus compatible boards that won't lose their memory when you lose your power.

The BP-0220 and the BP-0200 are nonvolatile 16K CMOS/RAM boards designed, developed and manufactured in the U.S. by NEC Microcomputers. Both boards come complete with an on-board self-charging battery pack, so if the power goes off, your data will be protected for a full 7 days.

The BP-0220 supports 16- and 20-bit addressing and delivers a maximum access time of 450ns. It also has sockets that allow you to add either 8-2716 or 8-2732 industry standard EPROMs, (user supplied).

The BP-0200 has all the features of the BP-0220 except EPROM sockets. Both boards give you the kind of reliability you've come to expect from NEC.

If you need to retain critical data, remember the two new boards from NEC. They're unforgettable.

For more information about our growing family of Multibus boards, call or write our Product Manager, SBC Systems, NEC Microcomputers, Inc., 173 Worcester Street, Wellesley, MA 02180. Tel: (617) 237-1910.

TM*Multibus is a trademark of Intel Corporation.

NEC

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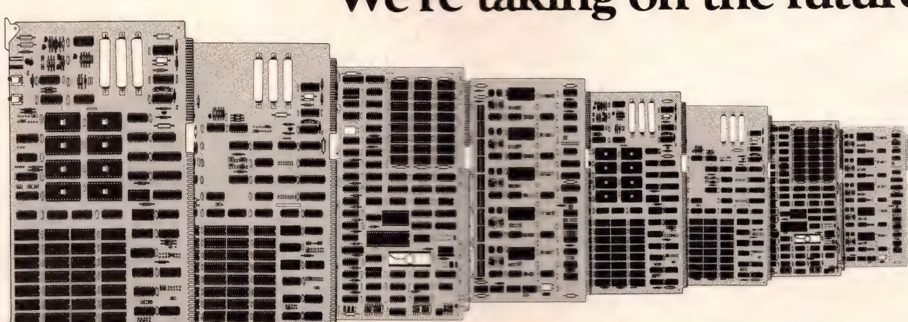


Signals & Noise

Other ways available to upgrade 8-bit systems

The article "An innovative TTL chip gives 8-bit μPs new life" (EDN, November 5, 1980, pg 269) effectively discusses address expansion—a needed first step in upgrading an 8-bit system.

Unfortunately, the article implies that increased processing power must come from a 16-bit CPU, which is not necessarily so. You can increase the throughput of an 8-bit system many times by using multiprocessor techniques, employing more than one 8-bit CPU and distributing the computing load among them.

However, you must design systems carefully to obtain the advantages of multiprocessing. An example of a good approach to multiprocessing is master/slave operation on the Multibus using our IM-1680 intelligent RAM, a 16k static-RAM board with an on-board Z80 that acts as a bus slave.

This arrangement results in a low-cost upgrade because the incremental cost of adding a CPU to a memory board is very small now that the price for a Z80 is less than \$10. And because every system must have memory, all you have to do to configure a multiprocessor is to use the IM-1680 intead of standard RAM boards.

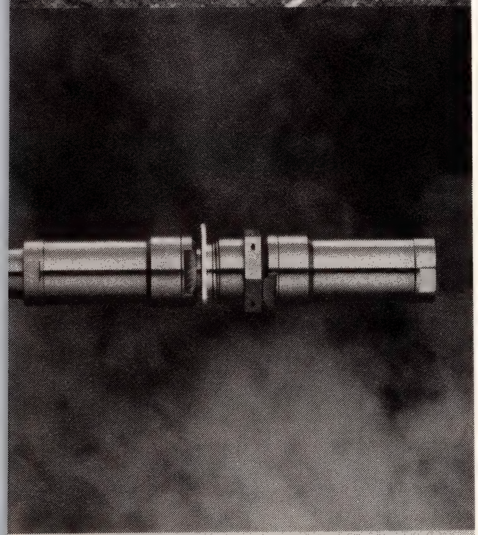
By using a memory mapper like the one described in the article and memory made up of several IM-1680s, you can build a system more powerful than one based on a 16-bit CPU. And a complete rewrite of the software isn't required to accommodate a new CPU. In addition, master/slave operation simplifies coordination of system software. Alternative configurations such as multimaster operation are much more difficult to program and offer no real advantage.

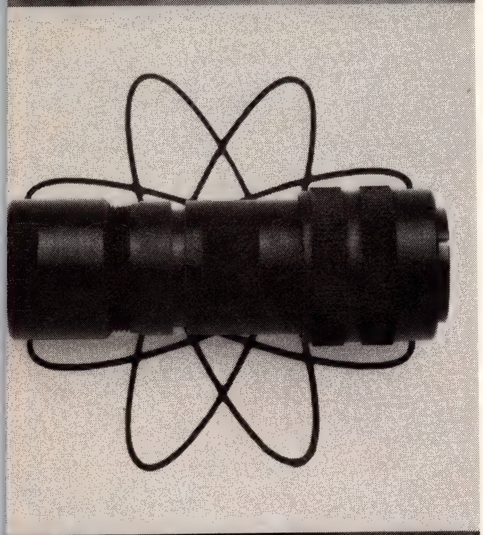
A multiprocessor's effectiveness depends on the amount of parallelism inherent in the software. Our experience has been that most programs can be easily partitioned to parallel-running subroutines, a practice that results in a modular and easy-to-maintain program. You can accomplish parallelism detection by hand or automatically using a preprocessor.

Although an upgrade of an 8-bit system might not be the correct solution in every situation, you should at least consider it before jumping to a 16-bit microprocessor.

Sincerely,
Vassilios J Georgiou
President
Microsignal
Santa Barbara, CA

"ON THE OTHER HAND, BOB, YOU'LL FIND A RATIO OF 2 MILLIMETRES MAYONNAISE TO 13 MILLIMETRES SALAMI WILL PROVIDE A MORE SATISFYING SANDWICH."





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Our firewall connectors are a prime example. Designed to penetrate the engine firewall of military and commercial aircraft with electrical circuits, our FRF/FVF series still maintain the integrity of the flame barrier requirements of the aircraft firewall.

These connectors protect against high temperatures, emergency fire-retardant conditions, moisture and atmospheric changes, plus resist fuels, cleaning agents, coolants and hydraulic fluids. They meet MIL-C-5015 Class K specifications.

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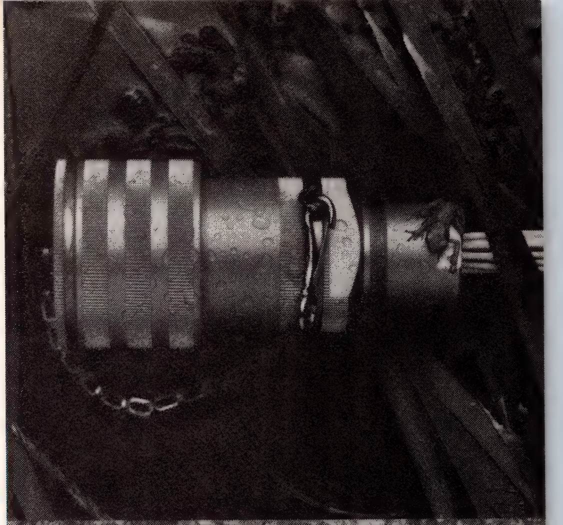

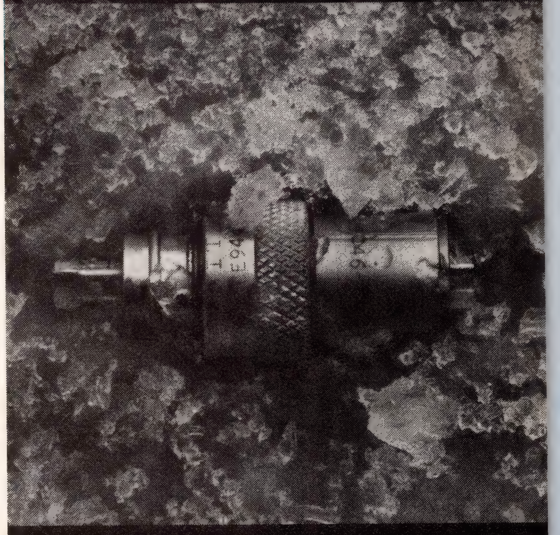

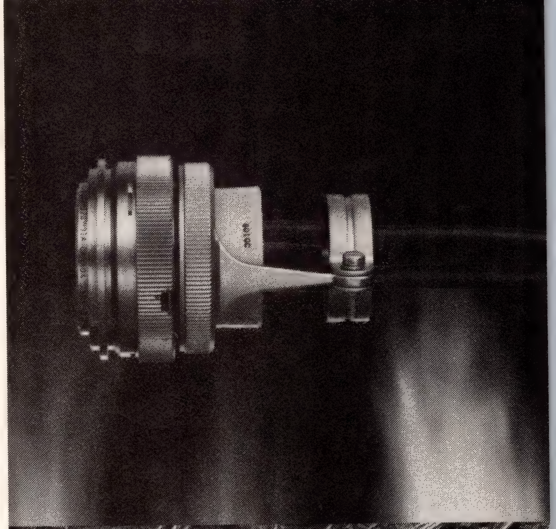

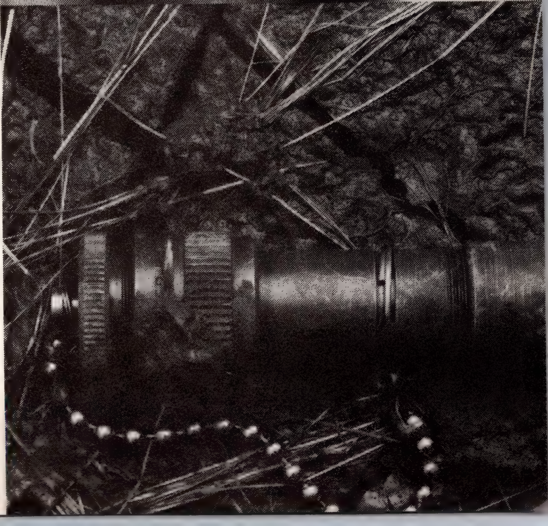

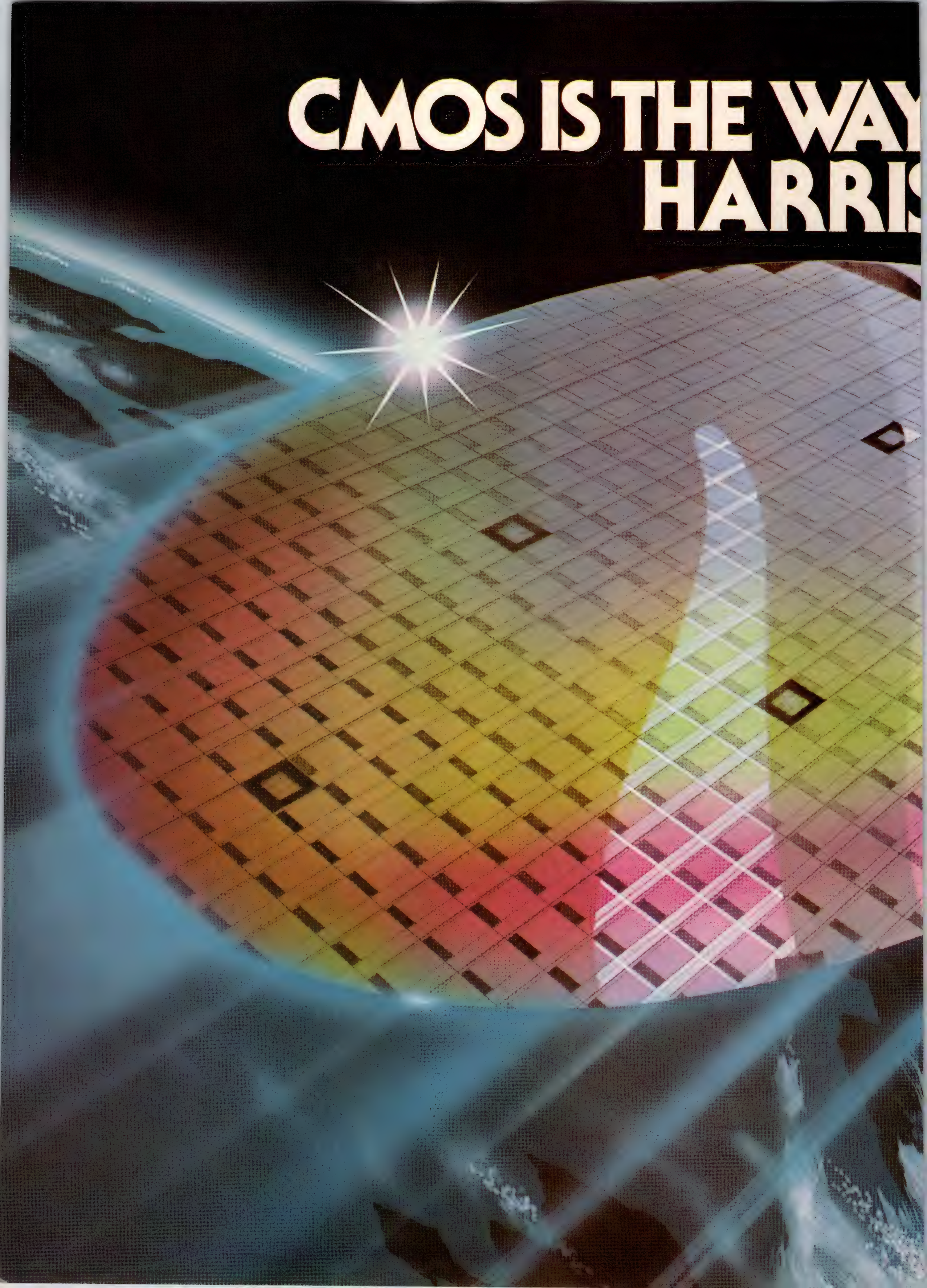
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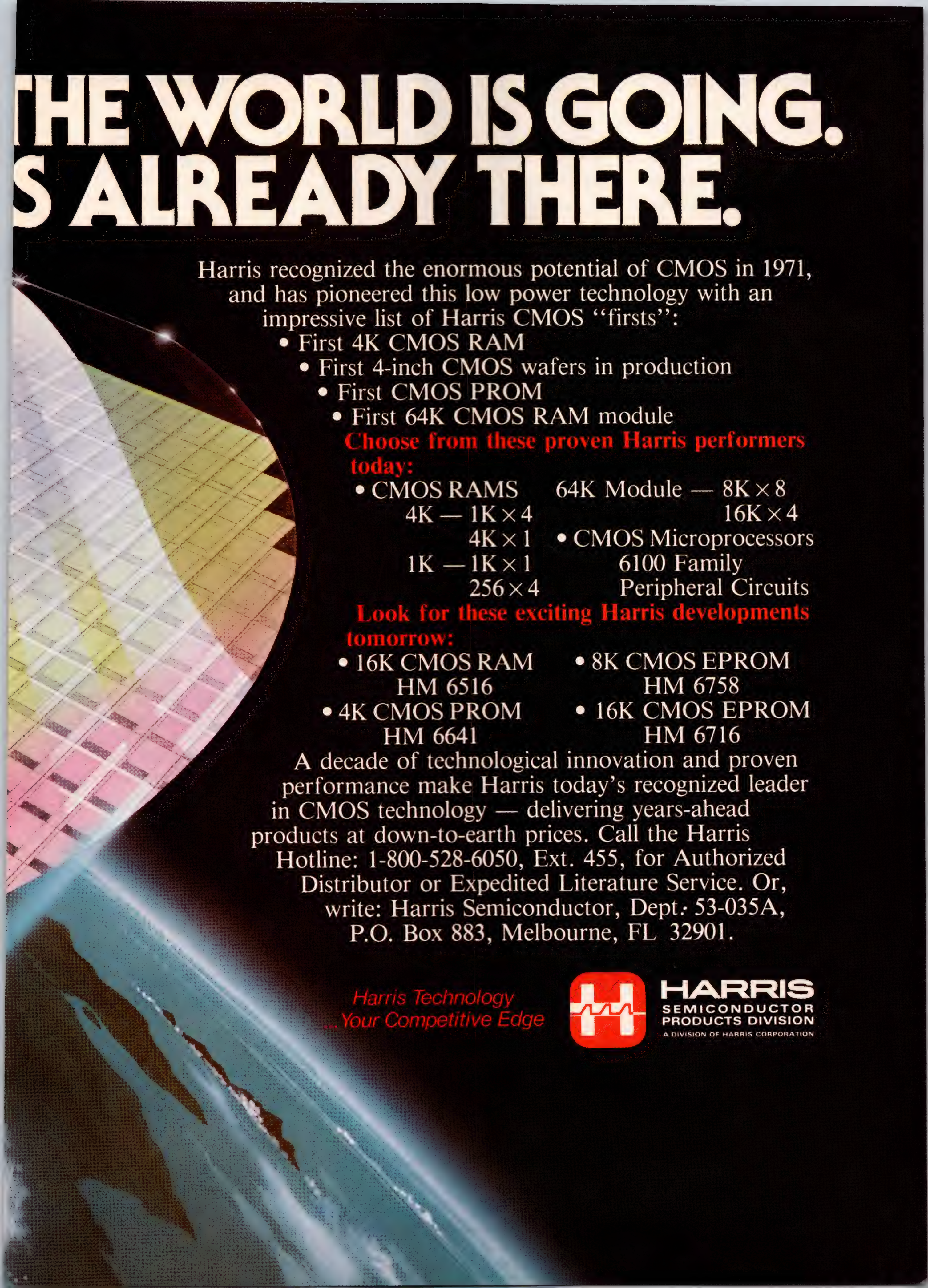
HARRIS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1K — 1K × 1
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Signals & Noise

The real breadwinner in the power-FET market

Dear Editor:

Congratulations to Bill Twaddell for his well-researched and -documented survey on power FETs (EDN, December 15, 1980, pg 116).

However, Bill's survey (like others on this subject) overlooked the real "jellybean" market for power FETs. Even though high-voltage, high-current and high-power devices provide the glamour and excitement, the dramatic growth in bookings, billings and profits currently lies with the industry's replacement of the ubiquitous 2N2222—a low-voltage, 500-mA, TO-92-style, n-channel enhancement-mode MOSFET.

Given the numerous benefits expounded by Bill's article for using power FETs, we at Siliconix were both surprised and pleased that with all the competitors entering the field, Siliconix alone offers the designer a viable option to the 2N2222—the VN10KM.

Even with this oversight, Bill's article is excellent.

Sincerely,
Ed Oxner
Staff Engineer
Siliconix Inc
Santa Clara, CA

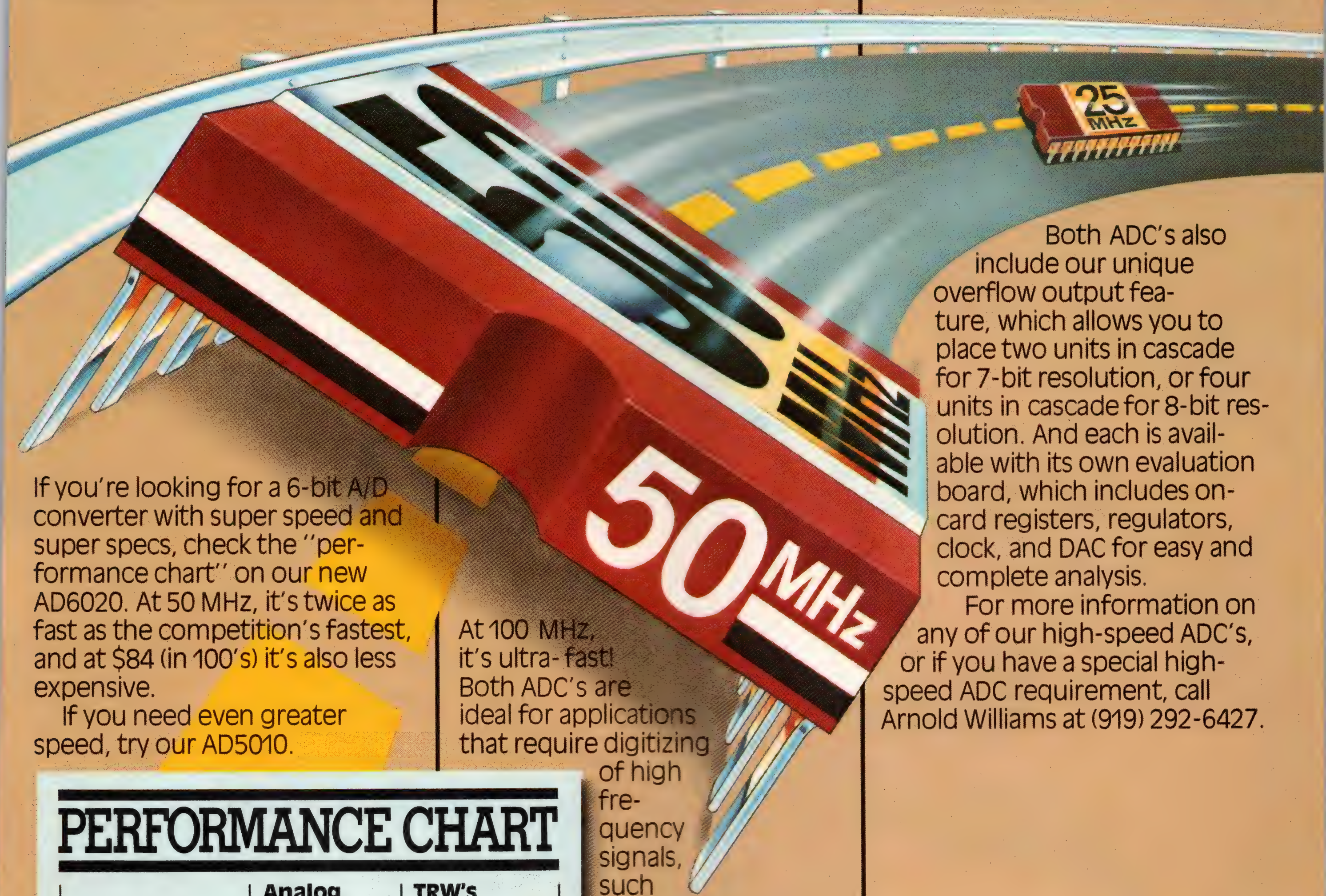
Firms can cheaply upgrade CRT terminals

Dear Editor:

EDN's November 20, 1980 editorial, "Only the strong will survive," gave designers bad advice when it suggested that new CRT terminals should "incorporate only those features that customers really want and need." If manufacturers built only "plain-Jane" terminals,

Continued on pg 28

IT'S A BETTER 6-BIT ADC FROM START TO FINISH.



If you're looking for a 6-bit A/D converter with super speed and super specs, check the "performance chart" on our new AD6020. At 50 MHz, it's twice as fast as the competition's fastest, and at $84 (in 100's) it's also less expensive.

If you need even greater speed, try our AD5010.

PERFORMANCE CHART

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Word rate	50 MHz	25 MHz
Power dissipation	450 mW max	750 mW max
Size	16 pin DIP	24 pin DDIP
Conversion time	20 ns	70 ns
Aperture jitter	25 ps	30 ps
Overflow	Yes	No
100's price	$84	$93
100 MHz available	Yes	No

At 100 MHz, it's ultra-fast! Both ADC's are ideal for applications that require digitizing of high frequency signals, such as in radar and X-ray equipment, medical systems such as ultrasound, and measurement instruments such as digital storage oscilloscopes and transient recorders.

Both ADC's also include our unique overflow output feature, which allows you to place two units in cascade for 7-bit resolution, or four units in cascade for 8-bit resolution. And each is available with its own evaluation board, which includes on-card registers, regulators, clock, and DAC for easy and complete analysis.

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For more information, Circle No 12

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That's because our GTH-based IDC II system completely eliminates the need for gold – in both the connector and the circuit board – *without sacrificing reliability!* That can mean a 33% cut in connector costs alone. Add to that the savings you enjoy by eliminating gold on the circuit board and you're talking about savings of 60% and more. And you get all this in addition to all the convenience features you've always wanted in an IDC connector.

So why settle for less in an IDC ribbon-cable connector system when you can have it all – and save money, too! Check our performance data. Then check our prices. Call me for quick action. Or write: Jack Miller, VP Marketing, Components Group, Burndy Corporation, Norwalk, CT 06856.

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Proof of Performance* (Contact Resistance based on #28 AWG Str.)

Conditioning	Milliohms Min.	Milliohms Max.	Milliohms Avg.
Test Group 1			
Initial C.R.	5.37	6.25	5.54
After Durability (25 Cycles)	5.73	7.28	6.32
After Durability (50 Cycles)	6.39	12.43	7.84
Test Group 2			
Initial C.R.	4.74	6.42	5.23
After Vibration & Shock	5.06	7.69	5.55
After Humidity	5.18	14.50	6.46

Conditioning	Milliohms Min.	Milliohms Max.	Milliohms Avg.
Test Group 3			
Initial C.R.	4.83	5.62	5.07
After Thermal Shock	5.08	6.61	5.55
Test Group 4			
Insulation Resistance (1,000 VAC for 1 Minute)	$>7\times10^4$	$>8\times10^4$	$>7.5\times10^4$
Dielectric withstanding Voltage (No Breakdown @ 500 VAC)	—— PASSED ——		

*Write for complete test data.

IDC II connectors available through your local Burndy Distributor.

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Signals & Noise

competition would exist only at the cheapest, me-too level.

If you design a CRT terminal wisely, you can add a dozen or so features for very little extra cost—just pack the power of software into the inexpensive RAM and ROM. Then, when you put the product on the market, one or more of those bells and whistles might just give your unit the selling edge over your competitors.

Of course, this strategy backfires if the extra features cost too much and/or if they stretch out the unit's engineering design cycle to the point that the competition beats you to the market. Still, these design challenges offer sales rewards that justify the extra effort it takes to succeed.

Sincerely yours,
R C Nocella
Natick, MA

(Ed Note: Mr Nocella's points are well taken. However, adding extra features at minimum cost is indeed a tough design task. Moreover, large competitors, if they capture a significant market share, will enjoy significant economies of scale. This imbalance will force smaller companies to seek narrow market niches, servicing specific customer groups that will pay only for specific combinations of product features and capabilities.)

Is it an analog or digital world?

Dear Editor:
Jim Williams's article, "A few proven techniques ease sine-wave-generator design," (EDN, November 20, 1980, pg 143) was very informative but a little disappointing—it made no mention of the digital generation of sine waves.

Because we live in a digital world, this important technique for generating high-quality, low-frequency sine waves (*IEEE Transactions on Instrumentation and Measurement*, Vol IM-18, June 1969) should not be sacrificed to appease the analog gods.

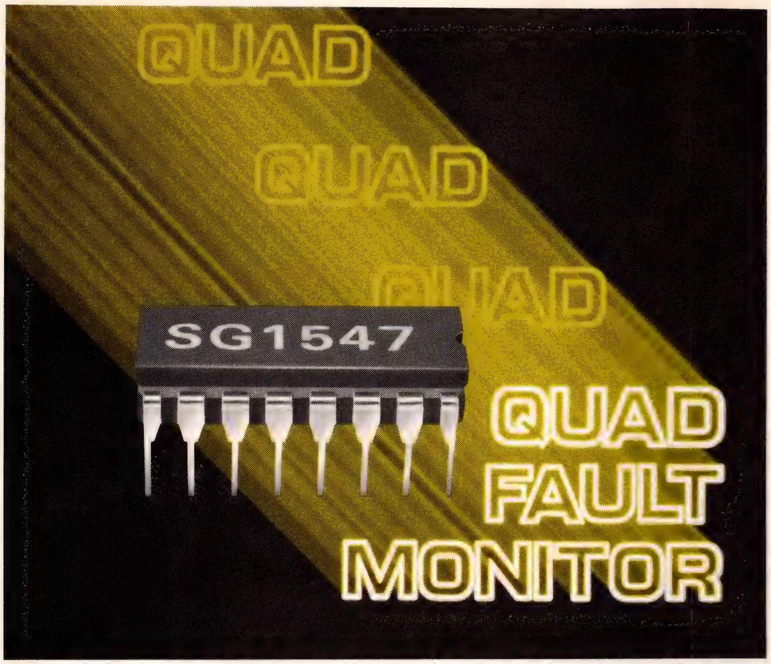
Very truly yours,
William D Kraengel Jr
Valley Stream, NY

Author's reply

Mr Kraengel is obviously misinformed—the *real* world is analog. Besides, one good op amp is worth a thousand microprocessors.
Jim Williams

Editor's addendum

Add another operating system to EDN's μC Operating Systems Directory (November 5, 1980, pg 301). SDS/DOS from Scientific Data Systems Inc meets development- and general-purpose OS requirements. The software aims at 6502 8-bit CPUs using a 6502 macro assembler, extended BASIC and a data-management system. Available since June 1977 at a cost that depends on configuration, it resides in 32k bytes of RAM and on a 1.25M-byte diskette. Network support includes file transfers via RS-232C and a proprietary SDLC setup of as many as 255 nodes over a 1-km coaxial cable. For a listing of the OS's peripheral-, memory- and file-management capabilities, as well as other key characteristics, **Circle No 370** or contact the firm directly at 344 Main St, Venice, CA 90291; phone (213) 390-8673.

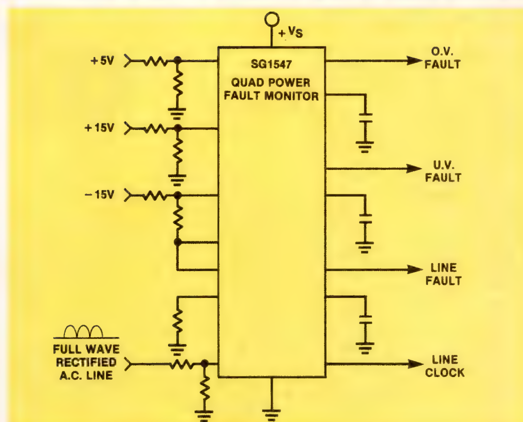


Our new SG1547 provides all the functions necessary for monitoring multiple power supplies. This compact IC can monitor three DC supply voltages for over- and under-voltage faults and simultaneously monitor an AC line for brownout conditions. Programming total power supply fault tolerance from 0% to 25% is easy, requiring just one external fixed resistor. Externally-programmable filter and delay circuits eliminate false fault reports. Built-in hysteresis on all comparators assures clean transitions without oscillation.

The SG1547 lowers design and manufacturing costs and improves reliability by eliminating many of the components associated with power monitoring. An internal reference, trimmed to 1% tolerance, eliminates many adjustments as well. The separate under-voltage, over-voltage and line fault outputs all feature high sink current and can be pulled up to 40V or be used directly to drive 5 TTL loads . . . with no external resistors.

Make your system safe from faults with our four-way monitor

TYPICAL MONITORING CONFIGURATION



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the power in power control IC's

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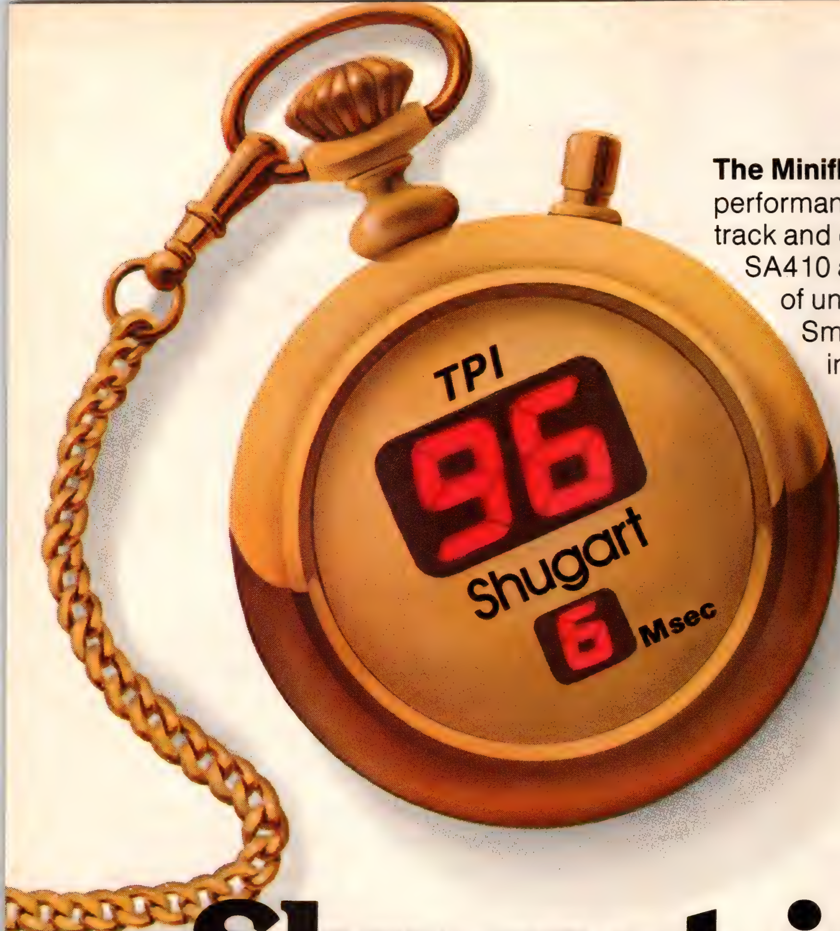
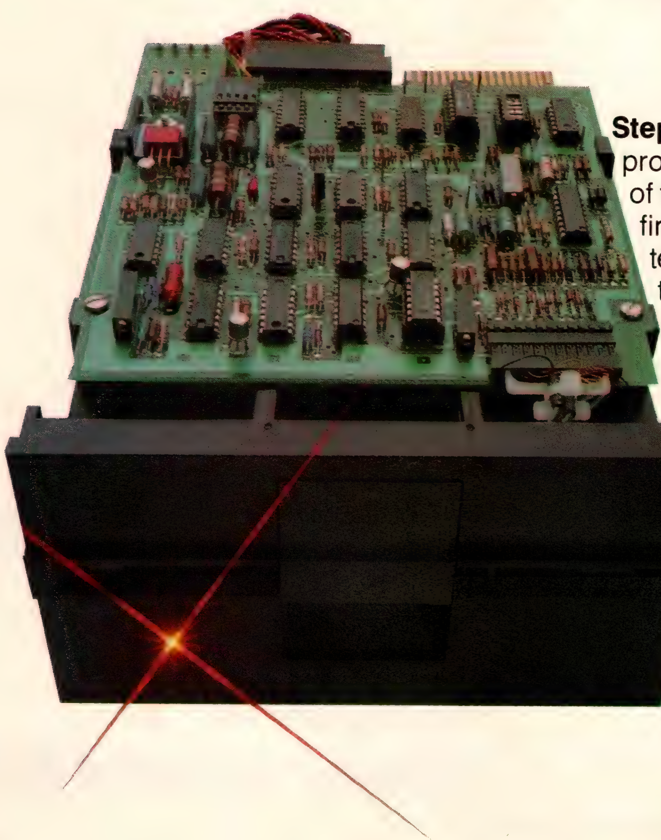


The Minifloppy tradition. The standard is set for high-performance 96 TPI Minifloppys. And it's by Shugart. Double track and double density, the single and double-sided SA410 and SA460 Minifloppys deliver .5 or 1 MBytes of unformatted capacity on a 5¼-inch diskette. Small wonder. Designed by the company that invented the Minifloppy, the SA410 and SA460 represent the culmination of all previous 5¼-inch disk drive technologies. What you get today is the most thoroughly engineered, most manufacturable, and most reliable Minifloppy drive available. The SA410/460 are the new standard in the eighties for price, performance, and capacity.

Shugart introduces of Minifloppys.



Step into the future. Innovation, experience, and proven performance have always been the hallmark of the Minifloppy tradition. And the SA410/460 are the first of the next generation in that tradition. Utilizing technology proven in our 8-inch disk drive products, the SA410 and SA460 use a multi-step positioning technique, thus eliminating pole asymmetry, an inherent source of positioning errors and degraded performance. The simplicity of this multi-step positioning motor and the HeliCam lead screw follower insure its manufacturability, consistent high performance, reliability, and low cost.

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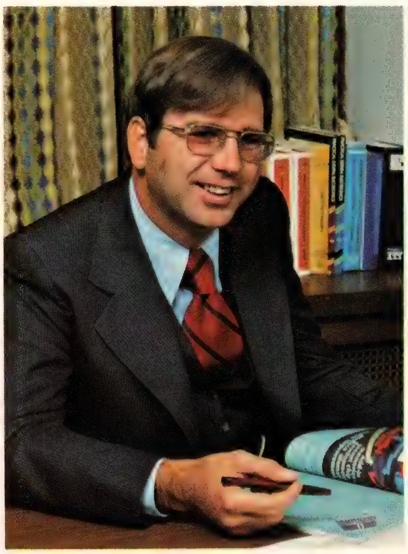
Editorial



Robots—Promise and peril

The headline of a recent short Associated Press news report was certain to capture any EE's attention: "Test robot attacks itself, suffers dislocated shoulder."

The story explained how a $50,000 aluminum robotic arm went out of control and slammed itself into its supporting stand before the man controlling it could hit the Kill switch. "Luckily, nobody was in its reach or grasp," said the controller, a graduate student in the University of Florida's Mechanical Engineering Dept. Indeed, luck was the student's ally, because the arm, measuring 5 ft long and weighing 70 lbs, could have inflicted serious injury if a person had been in the wrong place at the critical moment.

The incident, attributed to a hardware failure, "pointed out the dramatic need to us for robotic safety devices. As of now, there's really no way to prevent injury if a failure occurs," claimed the student.

What a chilling thought! Robots are widely touted as a promising solution to the US's productivity crisis, and research and development of industrial robots is accelerating rapidly. Indeed, many engineers will find challenge and opportunity in designing robots of all types.

Perhaps, then, the timing of the University of Florida accident was fortuitous, because it can serve to reawaken engineers to the fact that their creations can malfunction, creating problems ranging from mere inconvenience to life-threatening disasters.

Devotees of science fiction have undoubtedly read many novels describing the awesome consequences of robots running amok. Well, robots are no longer a dream of the future. And their arrival gives new meaning—and urgency—to fail-safe engineering.

Walt Patstone
Editor

An Award*-Winning Magazine
1978 Staff-Written Series — System Design Project
1978 Contributed Series — Designer's Guide to Fiber Optics
1977 Contributed Series — Software Design Course
1976 Special Issue — Microprocessor Reference Issue
1975 Staff-Written Series — Microprocessor Design Series

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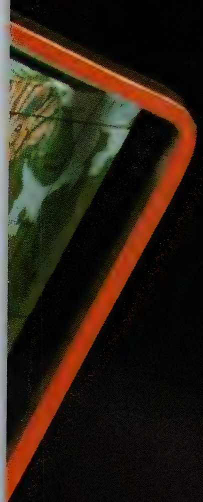

When C. Columbus challenged the status quo, a surprising thing happened to our world.

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Signal fidelity. With most scopes, matching input impedances requires an external 50 Ω termination. On the HP 1700 Series, and our new fully programmable 1980 Oscilloscope Measurement System, switchable 50 Ω input terminations are built in to insure faithful reproduction of input signals

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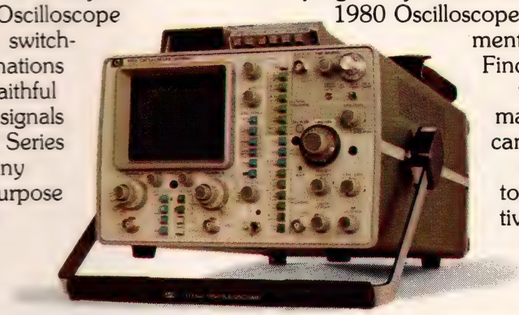

081/1

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If you're considering the purchase of an oscilloscope, call an HP Field Engineer or use our coupon for a no-obligation demonstration. In return, we'll give you a distinctive square-world coffee mug.

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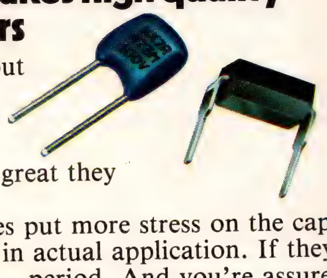
Union Carbide makes high quality ceramic capacitors



We've learned a lot about monolithic ceramic capacitors since we entered the industry in 1968, especially how great they can perform.

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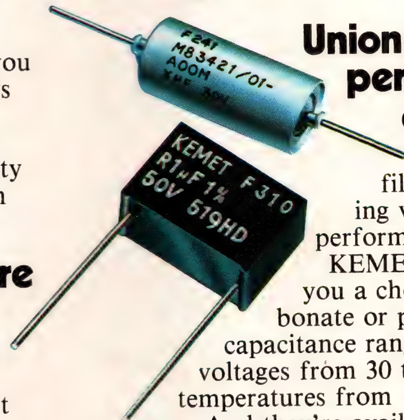

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For more information, Circle No 20

Leadtime Index

PASSIVE COMPONENTS

PRODUCT	LEADTIME IN WEEKS Min.	Max.	Trend
CAPACITORS			
Ceramic, disc	7	15	=
Ceramic, monolithic	8	21	=
Electrolytic, aluminum	5	14	=
Electrolytic, tantalum	7	16	=
Film	7	16	=
Mica	8	22	=
Paper	4	16	=
Trimming	9	15	=
CRYSTALS, FILTERS AND NETWORKS			
Filter, active	13	17	=
Filter, EMI	8	16	=
Filter, lumped-constant	6	14	=
Filter, quartz (monolithic)	13	21	=
Freq. determining crystal	7	14	=
ENCLOSURES			
Custom	6	9	=
Modified standard	7	10	=
Standard	6	9	↓
FANS AND BLOWERS	16	26	=
FRACTIONAL HP MOTORS	17	20	=
INDUCTIVE COMPONENTS			
Coil	11	15	=
Solenoid	7	12	=
Transformer, power	9	12	↓
Transformer, other	9	12	↓
INTERCONNECTION COMPONENTS			
Back panel	8	16	=
Flat cable	20	29	=
Multipin circular high-density	25	37	=
Multipin circular standard	18	37	=
Packaging panel	8	13	=
PC, one-piece	5	15	=
PC, two-piece	5	15	=
Rack and panel	11	34	=
RF coaxial	15	32	=
Socket	3	14	=
PRINTED CIRCUITS			
Double-sided	6	10	=
Flexible	6	14	=
Laminates	5	10	↓
Multilayer	8	11	=

PRODUCT	LEADTIME IN WEEKS Min.	Max.	Trend
PRINTED CIRCUITS			
Single-sided	5	10	=
RELAYS AND TIMERS			
Crystal can	6	20	=
General purpose	5	17	=
Miniature (TO-5, square)	8	15	=
Reed, dry	6	11	=
Reed, mercury-wetted	5	9	=
Solid state	5	14	=
Telephone	8	13	=
Time delay and timer	6	13	=
RESISTORS, FIXED			
Carbon film	3	15	=
Composition	6	18	=
Metal film	6	16	=
Network	8	14	=
Wirewound	6	16	=
RESISTORS, VARIABLE			
Pot, nonprecision WW	4	14	=
Pot, precision WW	6	10	=
Pot, nonprecision comp.	7	15	=
Pot, precision comp.	6	10	=
Trimmer, WW	6	11	=
Trimmer, comp.	9	11	=
SWITCHES AND KEYBOARDS			
Circuit breaker	8	14	up
Dual in-line	6	10	=
Keyboard and keyswitch	7	11	=
Lighted pushbutton	6	18	=
Pushbutton	5	16	=
Rotary	4	12	=
Snap action	5	9	=
Thumbwheel	3	10	=
Toggle	6	14	=
TRANSDUCERS			
Pressure	6	15	=
Temperature	6	12	=
WIRE AND CABLE			
Coaxial cable	8	12	=
Flat and ribbon cable	5	10	up
Hookup wire	6	10	=
Multiconductor cable	10	13	=

Leadtimes are based on recent figures supplied to *Electronic Business* magazine by a composite group of major manufacturers and OEMs. They represent the typical times necessary to allocate manufacturing capacity to build and ship a medium-sized order for a moderately popular item. Trends represent changes expected for next month.

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Small-disk-drive product advances promise tough design decisions

Carl Warren, Western Editor

If you're expecting halcyon days ahead for small disk storage systems, both good news and bad await you. A host of new products—some already introduced, others planned—could widen your design options and indeed signal the start of a Golden Age of disk-storage-system design. But incompatibilities among those products and a general lack of standards could also herald stormy design seas.

Since EDN's last update on this product area (May 20, 1980, pg 59), several innovative products have made their debuts, including Seagate (formerly Shugart) Technology's ST-506 Microwinchester 5.25-in. rigid-disk drive. This unit has sparked introduction of a host of similar ones, all designed to suit designers' supposed requirements.

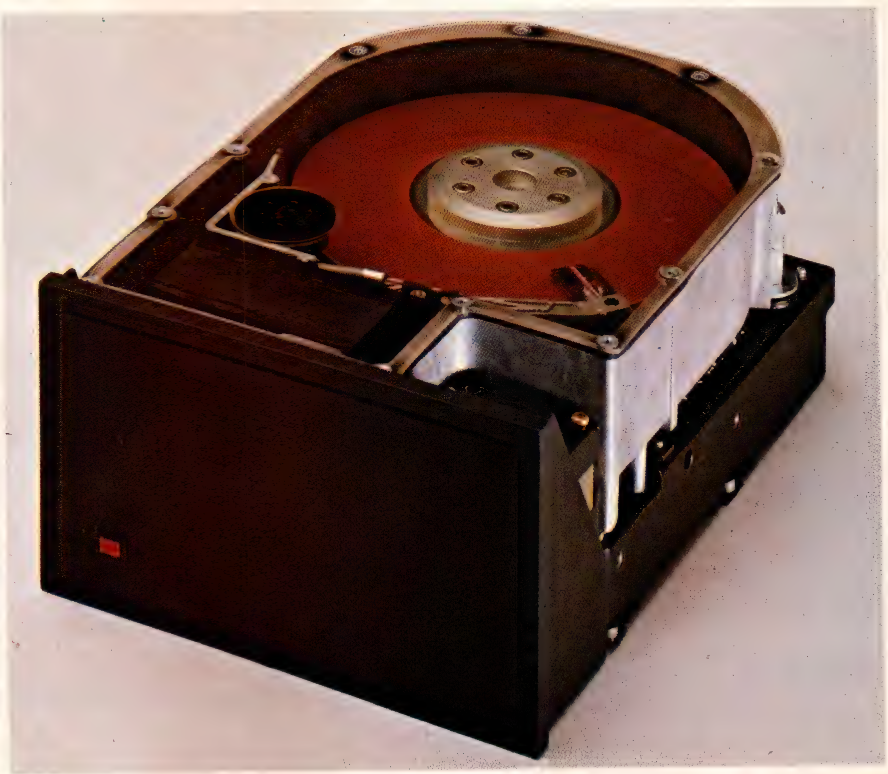
As consultant Ray Freeman, president of Freeman Associates (Santa Barbara, CA), points out, the new small rigid-disk drives represent more of an advance in packaging than in technology. Consequently, approximately 17 companies are in the process of announcing or planning such products. Noteworthy among the first announcements are units from Seagate, Shugart Associates, Tandon, New World Computer, Irwin International and International Memories (**Table 1**).

OEMs' considerations

Choosing among the offerings from these firms (and others) will be no easy task. Jim Porter, author of *Disk Trend Report* (Mt View, CA), observes that large OEMs will require drives from sources that can produce at least 1000 units/month. But other factors, some more important, will also influence OEMs' choices:

- **Pricing.** This negotiable quantity will probably carry the most weight as an OEM narrows the choices (see **box,** "Pricing 5.25-in. rigid-disk drives").
- **Capacity.** The requirements for this parameter are heavily application dependent. It ranges from 1.8M to 11.5M bytes in currently available units.
- **Second sourcing.** This factor calls for compatibility, especially in interfacing.
- **Access time.** Like those for capacity, the requirements for

Employing a plated medium, *dual impellers and temperature-compensation circuitry, the International Memories 5000 Series 5.25-in. Winchesters will initially be offered with 7M-byte unformatted capacity.*

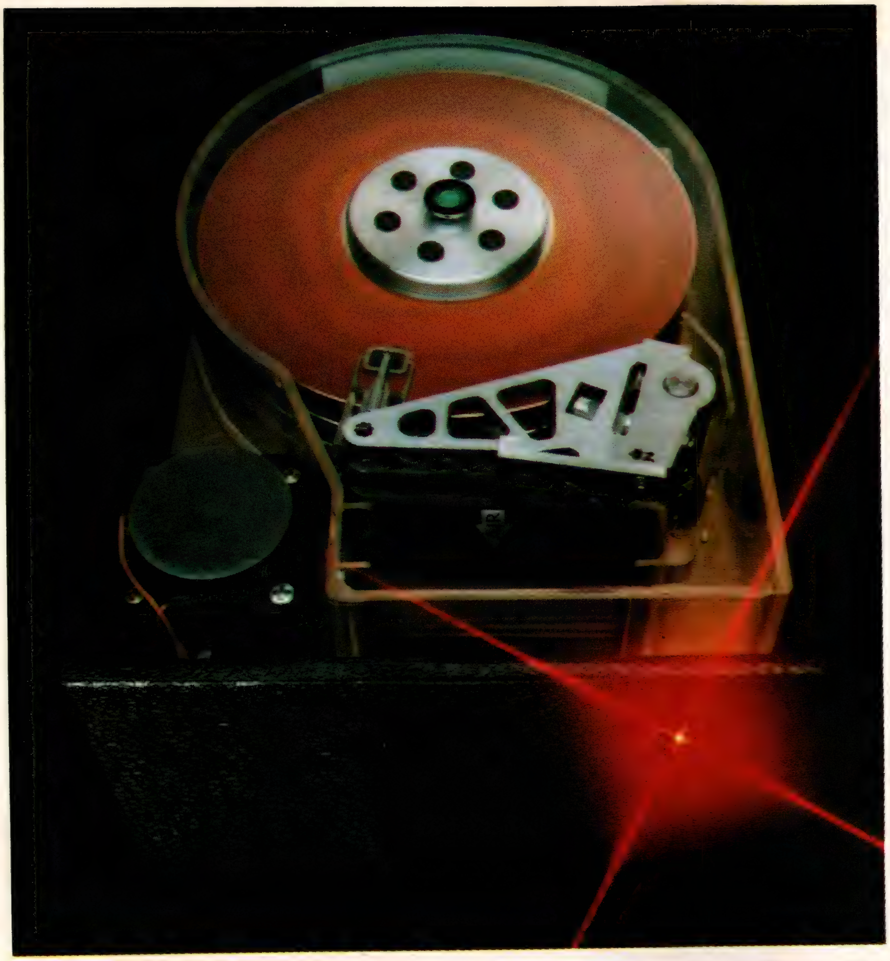


Available in six versions, *Tandon's TM 600 Series 5.25-in. Winchesters offer capacities ranging from 3.19M to 11.5M bytes. The units employ a rotary positioner.*

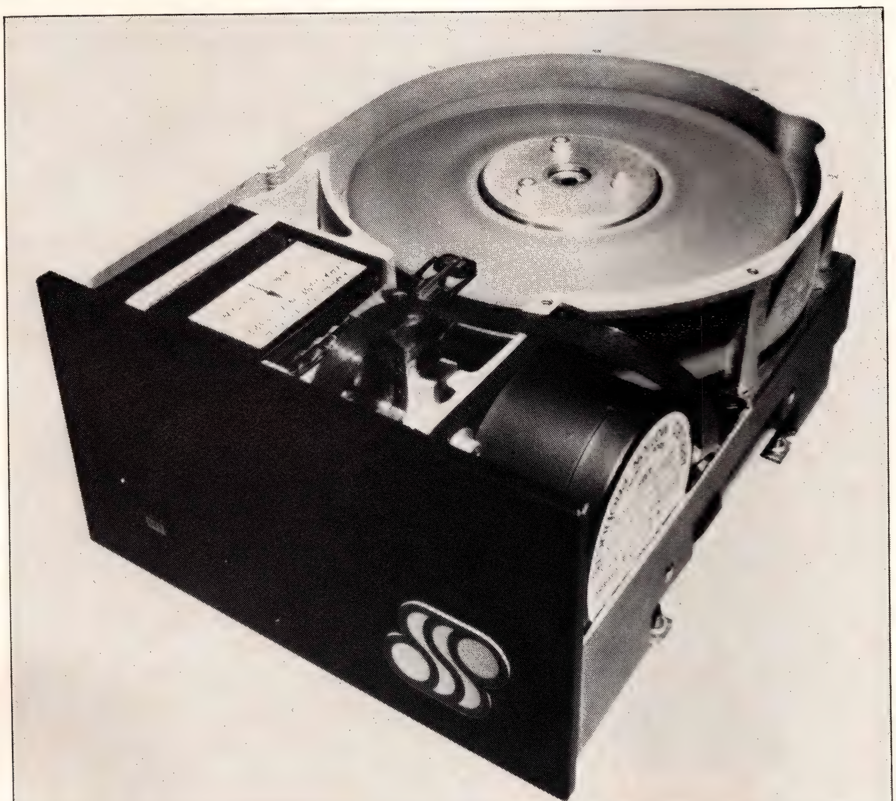
TABLE 1—TYPICAL 5.25-IN. RIGID-DISK DRIVES

MANUFACTURER	MODEL	UNFORMATTED CAPACITY (MBYTES)	INTERFACE	PRICE AND AVAILABILITY	CIRCLE NO
IRWIN INTERNATIONAL 200 GREEN RD ANN ARBOR, MI 48105 (313) 663-3600	510	10 (FORMATTED)*	N/A	$1500 (500) N/A	363
INTERNATIONAL MEMORIES 10381 BANDLEY DR CUPERTINO, CA 95014 (408) 446-9779	SERIES 5000	7 OR 14	SA1000 AND STD IMI UNIT	$800 TO $900 (1000) NOW	364
NEW WORLD COMPUTER CO 3176 PULLMAN ST SUITE 119 COSTA MESA, CA 92626 (714) 556-9320	MIKRO DISC V-1TF	1.8	UNDEFINED	$900 (100) NOW	365
OLIVETTI PERIPHERAL EQUIPMENT 525 EXECUTIVE BLVD ELMSFORD, NY 10523 (914) 592-2864	HD-561	6.38	MINIFLOPPY	$720 (1000) MARCH (EVAL) AUGUST (PROD)	366
	HD-562	6.38[1]	MINIFLOPPY	APPROX $850 (1000) MAX (EVAL) OCT (PROD)	
	HD-1512	11.7[2]	BIDIRECTIONAL BUS	$1230 (1000) JUNE (EVAL) MARCH '82 (PROD)	
SEAGATE TECHNOLOGY 360 EL PUEBLO RD SCOTTS VALLEY, CA 95066 (408) 438-6550	ST-506	6.38	SA1000	$925 (1000) NOW	367
SHUGART ASSOCIATES 435 OAKMEAD PARKWAY SUNNYVALE, CA 94086 (408) 939-7547	SA602	3.33	SA1000 AND MINIFLOPPY	$760 (500) APRIL (EVAL) JUNE (PROD)	368
	SA604	6.66	SA1000 AND MINIFLOPPY	$980 (500) APRIL (EVAL) JUNE (PROD)	
	SA606	9.99	SA1000 AND MINIFLOPPY	$1190 (500) APRIL (EVAL) JUNE (PROD)	
TANDON 9333 OSO AVE CHATSWORTH, CA 91311 (213) 933-6644	TM 601 TM 602 TM 603 TM 601E TM 602E TM 603E	3.19 6.38 9.57 3.83 7.66 11.5	SA1000 AND TM 100	LESS THAN $1000 (1000) NOW	369

NOTES
[1]HAS FASTER STEPPING MOTOR THAN HD-561 AND ACHIEVES 35-mSEC AVERAGE ACCESS TIME
[2]21-mSEC AVERAGE ACCESS TIME
*INCORPROATES 3M-TYPE MINI CARTRIDGE DRIVE FOR BACKUP



With two interfaces (SA1000 and Minifloppy), *Shugart Associates' Migid 5.25-in. Winchester drives incorporate electronic head-actuator damping to reduce head-mount flutter and thereby decrease head-settling time.*



With an unformatted capacity of 6.38M bytes *organized in 153 cylinders, Seagate Technology's ST-506 was the first 5.25-in. rigid-disk drive.*

this quantity are application dependent.

- **Vendor reliability.**

Design differences

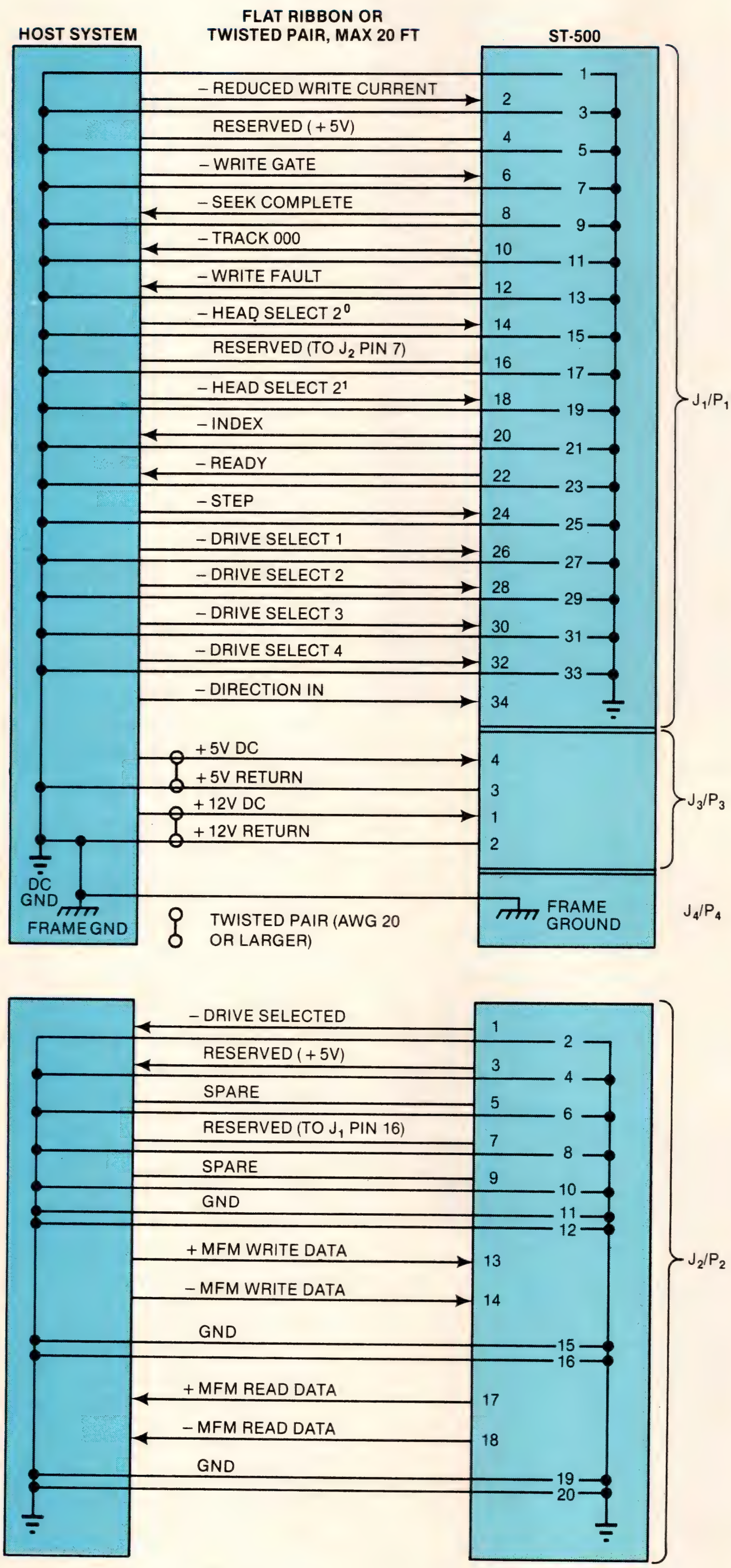
Although the 5.25-in. Winchesters from various manufacturers basically represent innovative packaging techniques, they exhibit some not-so-subtle technical differences as well. For example, Tandon's Models 601E, 602E and 603E (the E denotes "extended") are designed to use the entire disk surface, increasing the number of disk cylinders from 153 to 230 and providing a 20% jump in unformatted capacity compared with the firm's standard drives. The company achieves this advance by using a rotary actuator rather than a band device.

International Memories (IMI), on the other hand, employs a band actuator and a plated medium in its 7M-byte 5000 Series drive, slated for introduction this month. The drive, which will be expandable to 14M bytes, will be compatible with IMI's 8-in. units and will use dual impellers to cool the recording medium and electronics. It will also incorporate a temperature-compensation circuit for the band actuator as part of the basic design; marketing VP Frank Iazzetta points out that temperature control can be one of the more troublesome areas in a Winchester design.

Illustrating other technical differences are devices from Shugart Associates. In its Mini Rigid Drive (Migid) 5.25-in. units, the firm employs dynamic braking and an electronic damper to improve head-settling time. The damper keeps the head mount (flexure) from fluttering while the head is accessing a track.

Possibly the most unusual design, though, comes from New World Computer Co. The $900 (100) Mikro-Disc Model V-1TF is a modified version of standard Winchester designs, employing eight heads per data surface. These eight heads have simultaneous access to a portion of total storage equivalent to a Minifloppy 5.25-in. floppy-disk drive's capacity, permit-

TABLE 2 — SA1000-COMPATIBLE INTERFACE



SOURCE: SEAGATE TECHNOLOGY

ting track switching within this logical space at electronic rather than mechanical speeds. The heads also move together mechanically to gain access to other Minifloppy-sized areas.

Although the drive's capacity is limited (1.8M bytes unformatted), the simultaneous access to a Minifloppy-sized storage space is a plus. However, the unit is a sole-source design—a potential drawback.

De-facto standard?

Because Seagate Technology was the first to announce a 5.25-in. rigid-disk drive, many observers believe the company has established a de-facto standard for the small-Winchester interface in its SA1000-compatible configuration **(Table 2)**. Indeed, because of the firm's market lead, consultants like Freeman and Porter are advising their clients to opt for designs employing Seagate-lookalike interfaces. But that doesn't mean this interface is the only option.

Shugart Associates, for example, offers two interface choices in the Migid. One is an SA1000-type design similar to Seagate's but with pin 4 redefined for head select; the other supports the firm's Minifloppy and a Migid on the same daisy-chained line. Taking a similar approach with its TM 600 Series, Tandon offers an SA1000-compatible interface in a pin-to-pin duplication of Seagate's and a Minifloppy interface as well.

With a horde of other 5.25-in. rigid-disk drives due to appear, other interface approaches are likely. Still, the Seagate/Shugart/Tandon approach will probably be the "standard" one, so you'd probably do well to follow Freeman and Porter's advice. Note, for example, that IMI's forthcoming drive will incorporate an SA1000-compatible interface along with the firm's standard configuration.

Controllers are the key

Related to the problem of

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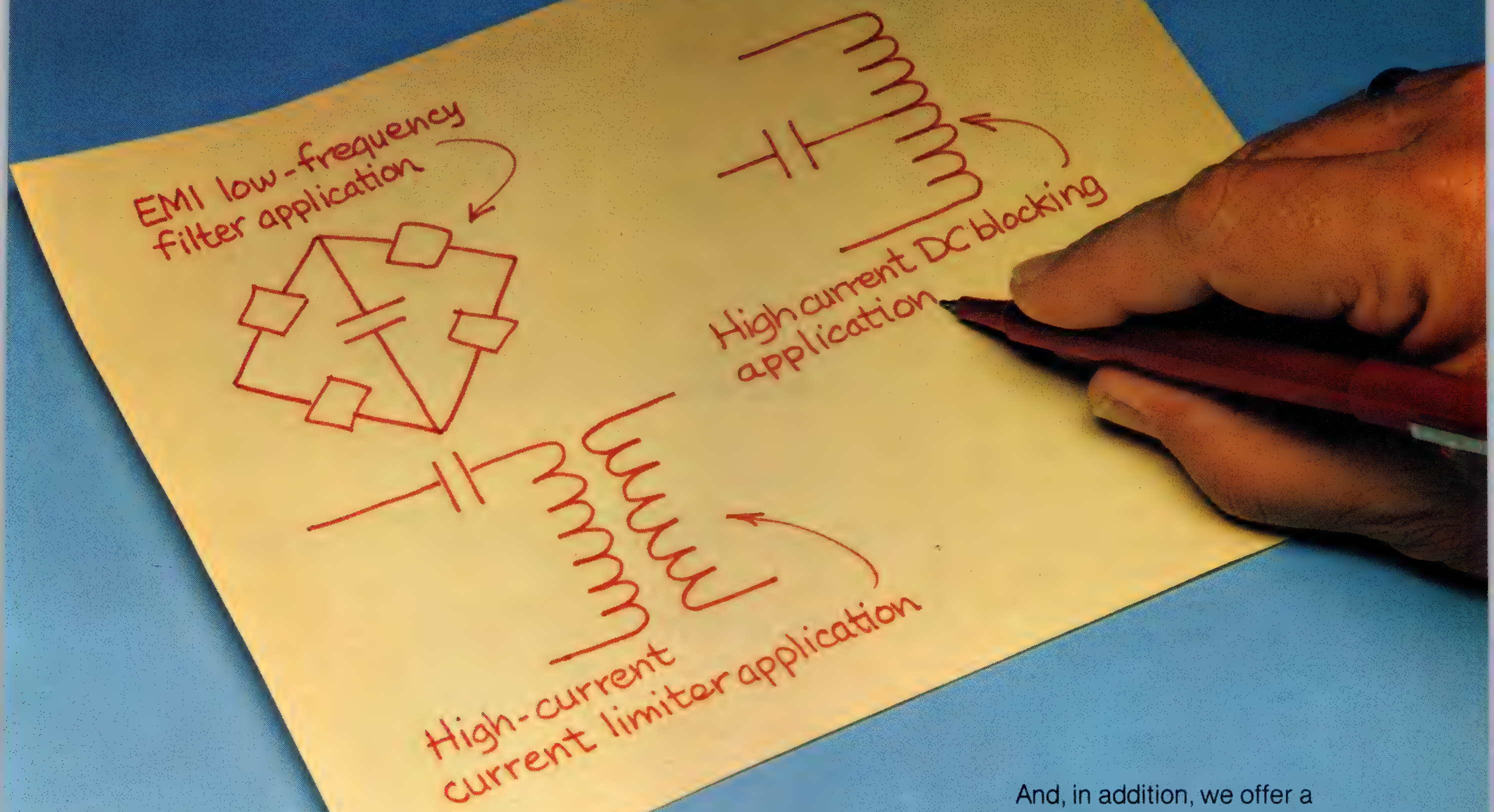
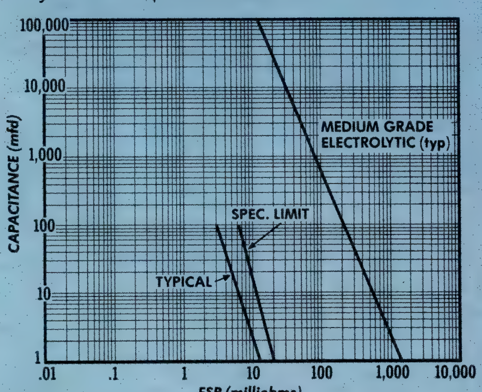


For switching power supplies the evidence is conclusive. Where a filter capacitance of 50 mfd or less will do, metallized polypropylene (film) capacitors far surpass electrolytics in impedance characteristics.



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interfacing the 5.25-in. drives is the design of their controllers. For although building a small rigid-disk drive apparently requires no technological breakthroughs, getting it to work *economically* in a variety of systems can present problems. Consequently, some observers believe that *cost-effective* controller design could be the one limiting factor on the growth of 5.25-in.-Winchester usage.

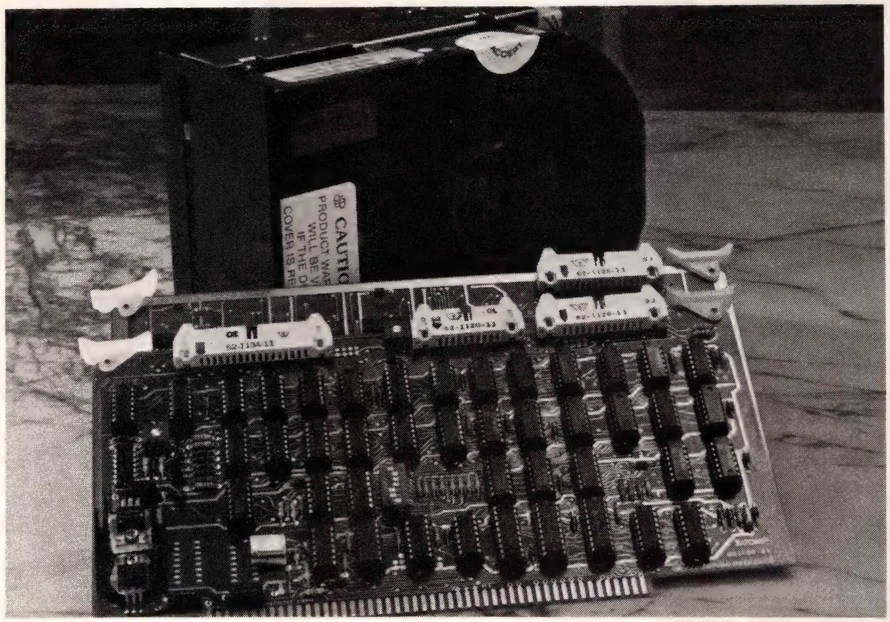
All of the drive manufacturers have been working closely with controller houses to develop adequate controller designs **(Table 3)**. And two of these designs are especially interesting.

Xcomp's controller supports a variety of rigid-disk drives. In this 2-board design, the data-control board employs specialized TTL processor circuitry that supports an instruction set geared specifically to controlling disk drives. In it, a writeable control store permits downloadable fault-tolerance testing from the host. The second (drive-specific) board provides the actual interconnection to a drive; depending on model number, this board supports units ranging from 5.25-in. Winchesters to 14-in. cartridge drives.

Xcomp's Models ST/S and ST/R controllers serve the Seagate Technology ST-506 drive. The ST/S interfaces with the S-100 bus and is IEEE-696 compatible, while the ST/R isn't oriented to a specific bus and requires only line drivers and receivers for matching to one. Each unit costs $980.

Another noteworthy controller is Alpha Systems' code-named "transformer," which is designed to plug directly into your current floppy-disk-drive controller anywhere on the daisy chain in multidrive systems. It tricks a µC system into viewing a 5.25-in. rigid-disk drive as the logical equivalent of approximately nine 40-track floppies.

Based on a Z80, the 50-in.² board fits in a standard Minifloppy enclosure, requires 5 and 12V (obtained from the primary control-



Incorporating a writeable control store *for fault-tolerance testing, the Xcomp 2-board controller easily handles the requirements of the Seagate Technology ST-506 Microwinchester 5.25-in. rigid-disk drive.*

TABLE 3—CONTROLLERS FOR 5.25-IN. RIGID-DISK DRIVES

MANUFACTURER	USE	CIRCLE NO
ALPHA SYSTEMS CORP 711 CHATSWORTH PL SAN JOSE, CA 95128 (408) 297-5583	GENERAL PURPOSE	347
AMERICAN COMPUTER & TELECOMMUNICATIONS 11301 SUNSET HILLS RD RESTON, VA 22090 (703) 471-6288	HEATH S-100 TRS-80	348
ANDICOMM TECHNICAL PRODUCTS 2603 COLLEGE ST TORONTO, ONTARIO, CANADA M5T 1P9 (416) 979-3328	S-100 APPLE	349
ANOVA CORP 760 LONGRIDGE RD OAKLAND, CA 94610 (415) 836-0800	MULTIBUS	350
CODATA SYSTEMS 285 N WOLFE RD SUNNYVALE, CA 94086 (408) 735-0800	MULTIBUS	351
CONTROL SYSTEMS 1317 CENTRAL KANSAS CITY, KS 66102 (913) 371-6136	GENERAL PURPOSE	352
DATA MANAGEMENT LABS 2148 BERING DR SAN JOSE, CA 95131 (408) 946-9424	S-100 MULTIBUS	353
DATA TECHNOLOGY CORP 2344A WALSH AVE SANTA CLARA, CA 95051 (408) 496-0434	GENERAL PURPOSE S-100 Z80 LSI-11 6800 SBC 80	354

Pricing 5.25-in. rigid-disk drives

A price war among manufacturers of 5.25-in. rigid-disk drives appears to be shaping up. And in the front lines is Olivetti Peripheral Equipment, which will offer its Seagate Technology-compatible HD-561 for $720 (1000) in August.

Other manufacturers view this pricing with mixed feelings. Some, such as Tandon VP Dan Taylor, observe that pricing is usually negotiable, depending on such factors as customers' ability to pay quickly (for which discounts are available). For this reason, some firms, such as Tandon, only quote ballpark pricing; Tandon's drives sell for "less than $1000 (1000)," and IMI's forthcoming Series 5000 will cost $800 to $900 (1000).

But other firms are adamant about the firm nature of their prices: Seagate Technology executive VP Finis Connor, for example, says the Seagate ST-506's $925 (1000) price tag is a legitimate benchmark. Similarly, Shugart Associates product manager John Sass says his firm's Seagate-lookalike Model SA604 is also competitively priced at $980 (500).

And what of Olivetti? Director of sales and marketing Gianni Subrizi claims the firm's currently quoted prices are well within established guidelines and will probably remain firm.

MANUFACTURER	USE	CIRCLE NO
DISTRIBUTED LOGIC CORP 12800 GARDEN GROVE BLVD SUITE G GARDEN GROVE, CA 92643 (714) 534-8950	LSI-11 PDP-11	355
KONAN CORP 1448 N 27TH AVE PHOENIX, AZ 85009 (602) 269-2649	S-100	356
LOBO DRIVES 935 CAMINO DEL SUR GOLETA, CA 93017 (805) 685-4546	S-100	357
MICROCOMPUTER SYSTEMS CORP 432 LAKESIDE DR SUNNYVALE, CA 94086 (408) 733-4200	IEEE-488 MULTIBUS	358
MORROW DESIGNS 5221 CENTRAL #2 RICHMOND, CA 94804 (415) 524-2101	S-100	359
PIICEON 2350 BERING DR SAN JOSE, CA 95131 (408) 946-8030	S-100	360
WESTERN DIGITAL CORP 3125 RED HILL AVE NEWPORT BEACH, CA 92663 (714) 557-3550	GENERAL-PURPOSE	361
XCOMP 7566 TRADE ST SAN DIEGO, CA 92121 (714) 271-8730	S-100 GENERAL-PURPOSE	362

ler connection) and incorporates a 1-track buffer. Priced at $425 (100), it's planned for full production this month and will work with Apple DOS, TRSDOS, and CP/M operating systems, for which the manufacturer will supply the necessary patches.

Be aware, though, that the "transformer" works at floppy-drive speeds, not Winchester ones. Thus, don't consider it for use in disk-intensive systems; confine it to single-user, single-station systems where speed isn't a major consideration.

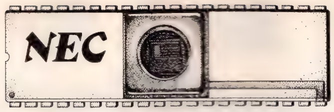
Floppy surprises coming

All of the innovations in disk-system products aren't in rigid-disk units; forthcoming floppies will pack a few surprises, too. For example, expect IOmega Corp (Ogden, UT) to introduce a very-high-density floppy by mid-year; this as-yet undesignated unit will use an 8-in. floppy medium enclosed in a plastic cartridge.

The medium will have rough (Bernoulli) surfaces that will permit it to essentially "float" in its environment, increasing reliability at the medium/head contact point. However, the drive won't employ contact recording at all; instead, it will use a flying head, as do the rigid-disk drives, and will store 8M to 14M bytes. It will operate at approximately 1500 rpm and use a closed-loop-servo head-positioning system.

Company president David Bailey says the drive won't employ a separate servo track but rather will write servo information on each track. Price will run about $1100 for the drive, and floppy cartridges will cost $30 each.

Also look for the introduction of removable cartridges for 5.25-in. rigid-disk drives by the third or fourth quarter, although availability might be sparse. But the real excitement will come not in obtaining these new disk-drive products, but in incorporating them into products that end users really need. **EDN**



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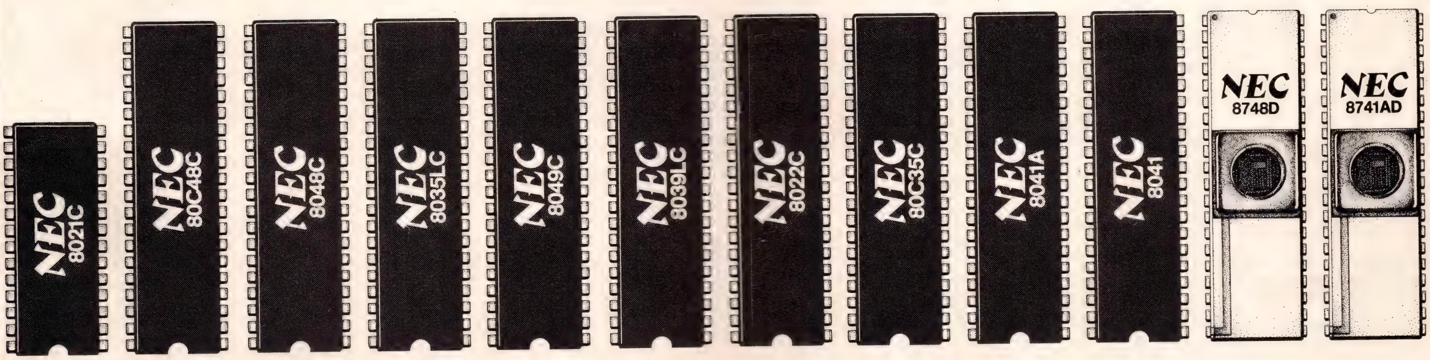

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Practical and blue-sky technology to share spotlight at ISSCC 81

John Tsantes, Eastern Editor

This year's annual International Solid-State Circuits Conference, traditionally a forum for semiconductor manufacturers to air their new developments and advances, will take on a new emphasis. No longer solely a conference reporting primarily on highly theoretical and experimental devices, the gathering will also focus on actual circuits that engineers could soon be designing with.

A review of the conference's more than 80 technical papers, coauthored by more than 300 experts from around the world, leaves no doubt regarding ISSCC 81's emphases: total system integration and unprecedented device performance. Both themes will be evident throughout the 3-day gathering's 17 daytime technical sessions and 10 evening panel discussions.

Of the various topics the conference will cover in New York City this month, semiconductor memories get extensive treatment. But conspicuous by their absence will be papers on ROMs, PROMs and EPROMs: Of the 16 papers to be presented during the three memory sessions—**session I** ("Static RAMs"), **session VIII** ("Memories and Redundancy Techniques") and **session XII** ("Memory Techniques")—only one, in the last-named session, deals with a ROM.

That paper, coauthored by Synertek's M Ebel, J Wong and P Sin, describes a 45-nsec fully static 16k MOS ROM that makes extensive use of small-signal amplification and 0V-threshold devices to reduce active power dissipation to 350 mW and standby power level to 75 mW. According to the authors, the device is contact-mask programmable and has a die area of 20,300 mil^2.

RAMs steal the show

The remaining memory-session papers will emphasize RAMs. And speed is definitely the name of the game here.

Leading **session** I will be a paper from Toshiba typifying the type of devices covered throughout the session. It will discuss an 18-nsec CMOS/SOS 4k static RAM.

According to Toshiba designers, although scaling techniques have permitted development of several NMOS 4k static RAMs with typical access times of less than 25 nsec, most of them exhibit high operating and standby power consumption. Additionally, even with low-power CMOS RAMs, access times much shorter than 40 nsec haven't been achievable. But by employing $MoSi_2$-gate CMOS/SOS technology with 2-μm gate lengths and 500Å gate-oxide thickness, Toshiba has developed a fully static 18-nsec 4k×1 RAM with 200-mW active power consumption and 50-μW standby power.

The Toshiba authors explain that the CMOS/SOS structure's low parasitic capacitance has improved minimum gate delay to 250 psec in a ring-oscillator circuit with single fanout. They also note that the sheet resistivity of $MoSi_2$-gate lines, typically as low as 3.5 Ω/square, drastically reduces the wiring RC delay along the word-select lines—to one-tenth that of a conventional polysilicon gate line.

The RAM, which uses the standard 6-transistor CMOS-flip-flop memory cell, features a 36×36-μm cell size. The entire chip measures 3.11×4.07 mm and is housed in a low-cost 18-pin plastic DIP. Address access time (T_{AA}), chip-select access time (T_{ACS}) and operating current (I_{CC}) are all functions of supply voltage (V_{CC}) **(Fig 1).** The authors point out that in this memory, address access time nearly equals chip-select access

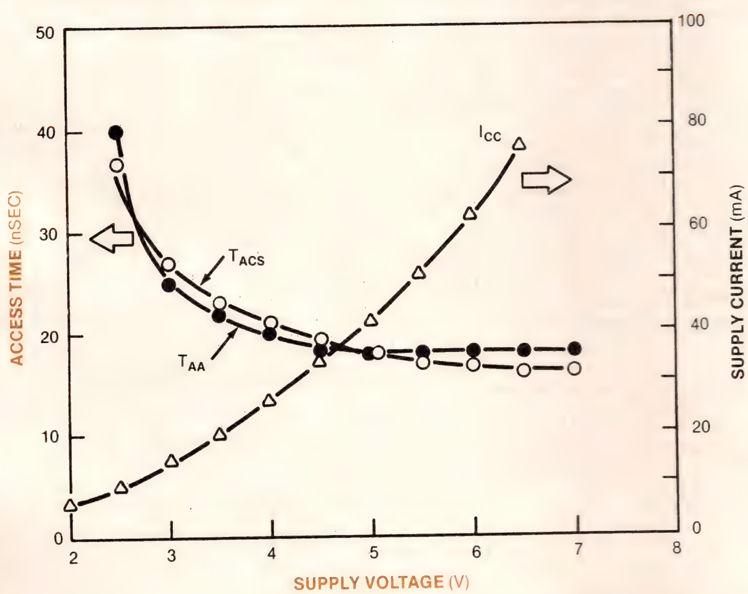


Fig 1—The performance *of Toshiba's CMOS/SOS 4k static RAM (to be discussed in ISSCC* **session I)** *varies with supply voltage.*

time, and read-cycle time equals access time.

Fast 16k static RAM

Texas Instruments has developed a 16k×1 fully static RAM exhibiting only slightly slower speed than the Toshiba device. Another **session I** paper will report on this 30-nsec part.

Coauthor Dan Kang, TI manager of static-RAM design, explains that the device utilizes a double-level-poly scaled-NMOS technology to achieve both this speed and a 600-mW power dissipation. The RAM is completely asynchronous and uses no bootstrapping techniques or clocking circuitry. Although Kang won't offer many details before the ISSCC, he does say that the device embodies a new architecture and many novel circuit-design techniques.

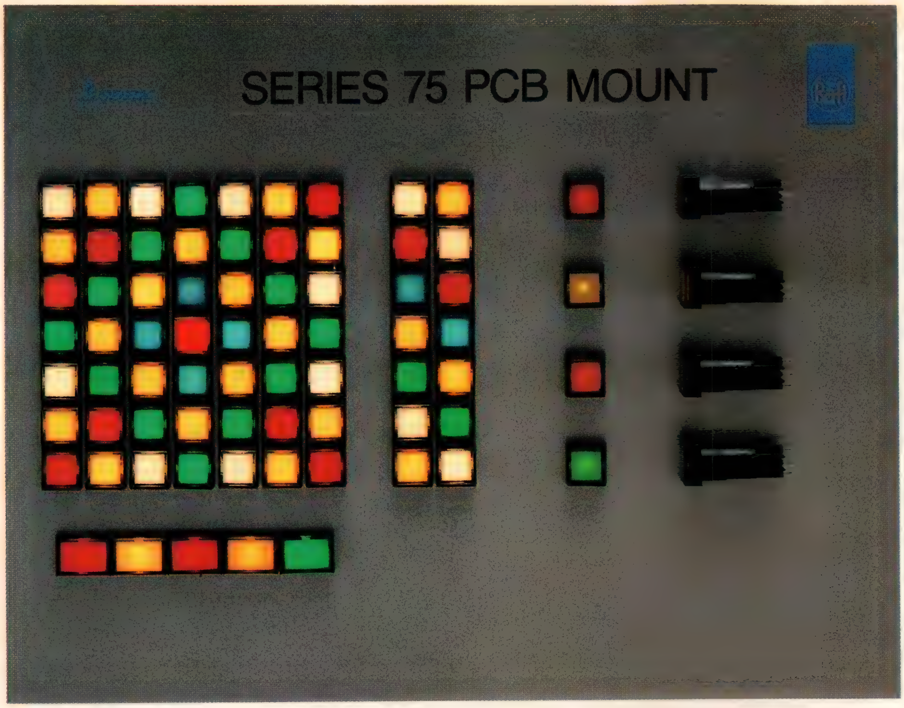
The design employs two 128×64 memory-array blocks and uses no redundant columns to compensate for bit faults. Its 158×256-mil memory chip will be housed in a 20-pin, 300-mil package.

Other new RAMs

Not to be outdone by TI and Toshiba, Hitachi will also report on a 4k static device in **session I.** Like the Toshiba part, this RAM specs an 18-nsec access time, but it uses a double-poly HI-CMOS II technology with 2-μm gate lengths rather than SOS to achieve its speed. At 150-mW power dissipation, it also runs a bit cooler.

Nippon Electric (NEC) will present two papers in **session I.** Countering TI's part, it will reveal its own 16k static RAM, spec'ing a 25-nsec access time. The device uses a double-polysilicon/molybdenum process technology to reduce RC delays to less than 1 nsec; it's designed with 1.5-μm rules.

A step above this 16k device is NEC's 64k static RAM, on which little detail is currently available. It, too, uses 1.5-μm design rules, and multiplexed addressing permits its assembly in a standard 300-mil,



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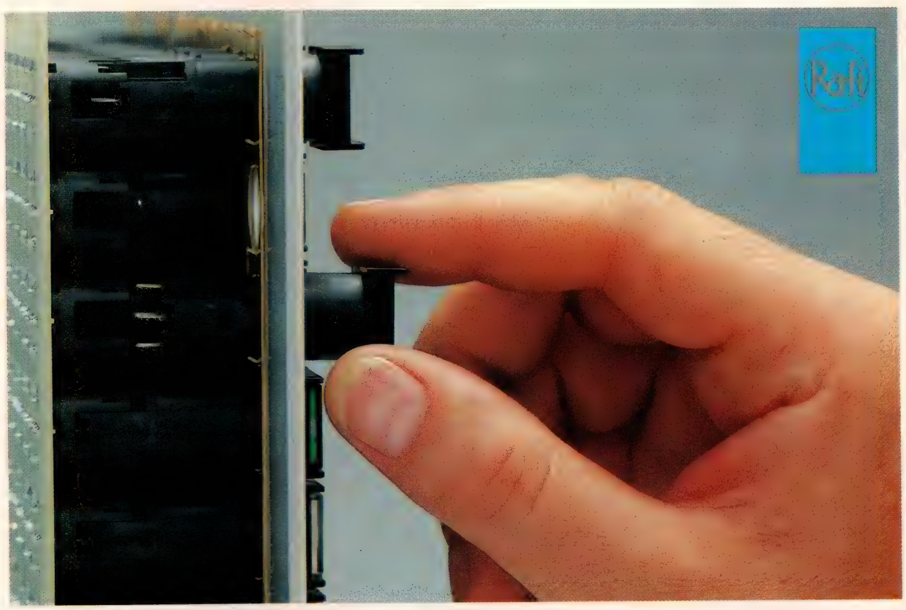

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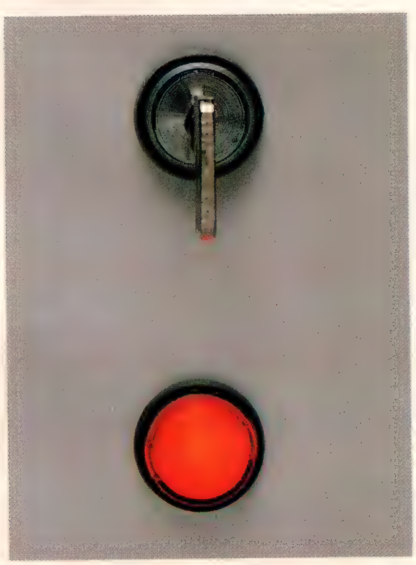

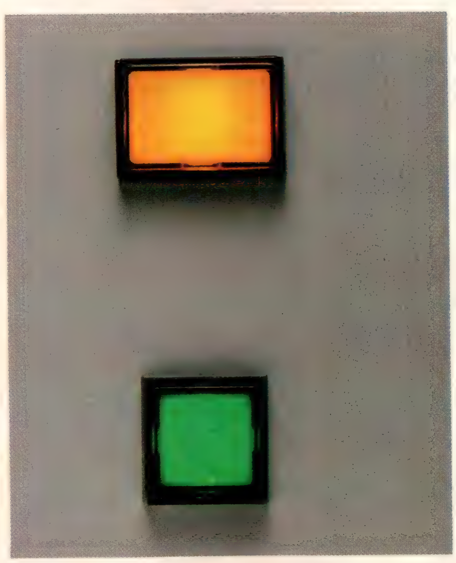

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Redundancy fights defects

As memory-device density increases, suppliers are realizing that high defect rates could turn otherwise high-performing parts into financial disasters. As a result, they're adding redundant circuitry to the high-density ICs as a means of keeping yields up and device costs down. While not too important at the sub-16k level, the technique is becoming a virtual necessity above that level.

Session VIII will deal with this subject in the first three of its five papers. Intel, for instance, is applying redundancy techniques to static RAMs and will discuss their impact on a 16k device. According to the company, for a 16k×1 static RAM with 40-nsec typ access time, the additional circuitry increases die area by approximately 6%, access time by 3 nsec and power requirements by only about 3%. Although Intel won't quantify the resulting yield improvements, it does term them "substantial."

Bell Labs *is* willing to give numbers: It claims a five- to 30-fold yield improvement in a 64k dynamic RAM and will discuss this improvement in **session VIII**'s second paper. Bell, which uses laser programming of redundant circuits in VLSI memories, claims that the improvement calls for less than 4% circuit redundancy.

Emphasis on systems

Although ISSCC 81's memory sessions and their superfast RAMs should drive the "performance" theme home to conference attendees, **session IX** ("VLSI Microcomputer Systems") should leave visitors with the feeling that the show is also stressing total system integration. And it should leave several jaws hanging, as well. Unlike other sessions, which are set up in one or two sections in the Empire State Ballroom at New York's new Grand Hyatt Hotel, this one has been slated for three large

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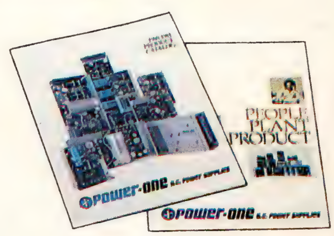

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rooms to accommodate an expected heavy turnout.

Although designers from Digital Equipment Corp and Integrated Circuit Systems will coauthor a paper on a 16-bit, 13,000-transistor NMOS microprocessor combining a minicomputer instruction set with a microprocessor bus, the session's really hot items will come from Intel and Hewlett-Packard. Both companies will officially unveil 32-bit processor systems. And although the talk from Intel is expected, the HP disclosure is likely to catch everyone by surprise.

Intel plans four papers describing the basic system philosophy and the three main chips of its iAPX-432 (EDN, November 5, 1980, pgs 103 and 198). With a cost of more than $30 million and a 5-yr development time, the iAPX-432 utilizes an architecture that's software transparent and accommodates multiprocessing through plug-in devices.

Scheduled for introduction in mid-year, the 32-bit 3-chip set, with a system performance equivalent to that of an IBM 370/158 mainframe (up to 2.5 million instructions per second), will initially cost $3000. Its price will drop to approximately $200 by 1984, according to an Intel spokesman.

The set includes a Micromainframe Execution Unit, a Computer Instruction Decoding Unit and an I/O Interface Processor, each treated in a separate **session IX** paper. The execution unit, a 355-mil-square chip, accepts, decodes and executes the continuous stream of microinstructions received from the microinstruction sequencer in the basic computer. The instruction-decoding unit contains more than 100,000 transistors and measures 320 mils square. It decodes the bit-aligned, variable-length instructions and produces the microinstructions and data necessary to execute them.

To make full use of this system's processing power, Intel has chosen a high-level language rather than assembly-language programming.

ISSCC 81 schedule details

The 1981 International Solid-State Circuits Conference is scheduled for February 18 to 20 at New York's Grand Hyatt Hotel. Advance registration fees are $50 for IEEE members and $70 for nonmembers; admission prices will be $60 and $80, respectively, at the door. All attendees will receive a copy of the 24th edition of the *ISSCC Digest of Technical Papers,* containing edited and illustrated condensations of all conference papers. Additional copies will be available at $20 to members, $30 to nonmembers.

Attendees can register any day during the conference between 8:00 AM and 4:00 PM in the Empire State Ballroom's foyer. Preshow registration, on Tuesday, February 17, will be held between 4:00 and 8:00 PM.

All 17 technical sessions, as well as the 10 informal evening panel sessions, will take place in the Empire State Ballroom.

You can obtain registration forms and additional information by contacting Lewis Winner, Box 343788, Coral Gables, FL 33134. Phone (305) 446-8193/8194.

ISSCC 81

	Timetable	Empire State Ballroom Foyer	EMPIRE STATE BALLROOM A	B	C	D	E
TUE FEB 17	4:00 PM 8:00 PM	Registration	—	—	—	—	—
WEDNESDAY, FEB 18	8:00 AM 4:00 PM	Registration	—	—	—	—	—
	9:00 AM 11:45 AM	—	**SESSION III** Solid-State Devices		**SESSION I** Static RAMs		**SESSION II** Consumer Circuits
	12:00 Noon 1:30 PM Lunch	—	—	—	—	—	—
	1:30 PM 2:10 PM	—	**SESSION IV** Formal Opening				
	2:15 PM 3:00 PM	—	**SESSION V** Keynote Address				
	3:15 PM 6:00 PM	—	**SESSION VIII** Memories and Redundancy Techniques		**SESSION VI** Data-Acquisition Circuits		**SESSION VII** Microwave Amplifiers
	6:15 PM 7:15 PM	—	Author Interviews		—	—	—
	8:00 PM	—	**INFORMAL DISCUSSION SESSIONS**				
			WE 1 Power GaAs-FET Amplifiers	**WE 2** VLSI Industry/University Interaction	**WE 3** CMOS vs NMOS for VLSI	**WE 4** Speech-Synthesis Techniques	**WE 5** ADC for Video Frequencies and Beyond
THRUSDAY, FEB 19	8:00 AM 4:00 PM	Registration	—	—	—	—	—
	9:00 AM 12:15 PM	—	**SESSION XI** Microwave Circuits	**SESSION IX** VLSI Microcomputer Systems			**SESSION X** Analog Filters and Oscillators
	12:15 PM 1:30 PM Lunch	—	—	—	—	—	—
	1:30 PM 5:00 PM	—	**SESSION XIV** Analog Techniques		**SESSION XII** Memory Techniques		**SESSION XIII** Advanced Circuit Applications
	5:15 PM 7:00 PM	—	Author Interviews		—	—	—
	8:00 PM	—	**INFORMAL DISCUSSION SESSIONS**				
			THE 6 Millimeter-Wave ICs	**THE 7** Packaging for VLSI Components	**THE 8** Design Methodologies for VLSI	**THE 9** The Selection of 16-Bit Microprocessor Families	**THE 10** Limits of Precision in Analog ICs
FRIDAY, FEB 20	8:00 AM 11:00 AM	Registration	—	—	—	—	—
	9:00 AM 12:15 PM		**SESSION XVII** Telecommunication Circuits		**SESSION XV** Advanced Process Technology		**SESSION XVI** VLSI Logic
	12:15 PM 1:15 PM		Author Interviews		—	—	—

It uses the object-oriented ADA language (EDN, January 7, pg 171), mapped directly into hardware, as the system's software format.

Density milestone

Not out to steal any of Intel's thunder, HP will nevertheless deliver a bombshell of its own during **session IX.** Out of the firm's Ft Collins, CO System Technology Operation comes what may be the highest density chip set ever seen in the industry.

Hewlett-Packard designers plan to describe this fully integrated 32-bit VLSI processing system, consisting of six chips housing as many as 600,000 transistors each. The devices include a 32-bit CPU, an I/O processor, a memory controller, a clock driver, a 128k RAM and a record-shattering 528k ROM.

One of the two papers HP will present, emphasizing the CPU chip's processing, will characterize the device's instruction set, performance, internal design and testing—an aspect the company feels is most critical. The second paper will discuss the design of the CPU chip itself as a vehicle for describing the process technology, which HP characterizes as a further advance in NMOS.

Also to be discussed is an outline of the process flow, the design rules and the overall system philosophy. Although HP won't prerelease any more data, a source does reveal that the VLSI devices are fabricated using optical lithography with a 2.5-μm pitch and double-layer metallization.

However, although the chips definitely constitute a "technological breakthrough," HP is quick to point out that the ISSCC disclosure won't be a new-product announcement. Indeed, no new products, just prototype devices, exist, according to the company. As with most of HP's semiconductor technology, the only way to obtain the fruits of this advance is to buy an HP system incorporating it. Although the company won't say when and if a product employing the 32-bit chip set will appear, it does say that

system implementation is still at least 1 yr away.

Telecomm emphasis remains

One application area continuing to receive increased emphasis from the semiconductor industry is telecommunications, and once again this year the ISSCC program committee has devoted an entire session **(XVII)** to this subject.

Last year, manufacturers were busy developing monolithic codecs in 1- and 2-chip sets. This year, the emphasis at ISSCC will be on single-chip devices incorporating on-board filters as well. Half of the **session XVII** papers will describe such devices from Hitachi, Bell Laboratories and NEC/NTT Musashina Electrical Communication Laboratory.

The Bell Labs CMOS chip, containing a codec, filter and trimmed voltage reference, requires only a few nonprecision off-chip capacitors for complete implementation. Power dissipation is a very low 60 mW, reducing the operating cost of the line interface. The chip is currently being sampled within the Bell system and is committed to manufacturing. It has an active area of 23.4 mm^2.

The Hitachi part, while only slightly larger (30 mm^2) than Bell's device, specs twice the dissipation (approximately 130 mW). It, too, is a fully integrated single-chip CMOS-filter/codec with an independent on-chip encoder/decoder, transmit/receive filter and band-gap reference source.

The circuit from NEC/NTT, on the other hand, dissipates a phenomenally low 35 mW. A PCM codec with accompanying filters, it's integrated on a 30.4-mm^2 chip and also uses CMOS technology. The device consists of an encoder/decoder, switched-capacitor filters and two PLL clock generators.

Applications abound

Another ISSCC session that attendees should find particularly interesting and informative is **session XIII,** "Advanced Circuit Applications." Of the seven papers to be presented, at least two will report on devices with far-reaching design applications—one in biomedical use and one in communications.

Intersil plans to describe a biomedical microprocessor with analog-I/O capability. Although it was initially designed for use as an implantable pacemaker, coauthors J Berman and J Prak say it can serve in other biomedical applications (such as neurostimulation) requiring monitoring and sensing of the low-level signals present in the body.

The device incorporates two amplifiers capable of sensing 0.5-mV haversine waves and two others with output-drive capability of 1 to 12 mA. The 35,600-mil^2 CMOS chip contains a 4-bit microprocessor implementing eight programmable modes.

The biggest challenge facing the Intersil designers, say the paper's authors, was the design and integration of the device's low-level sense amps. This accomplishment eliminates the use of separate amplifiers, which heretofore served to boost body-level signals to more usable levels.

Intersil designers consider this circuit the most advanced pacemaker ever developed; it replaces current designs using complex hybrids. Low-power CMOS technology allows the device to operate for 5 yrs on the 1.86V lithium batteries currently used in implantable applications. The part has its own set of built-in diagnostics and can be reprogrammed while implanted to adjust for characteristic patient changes.

Monolithic f-o receiver

IBM's contribution to **session XIII** will be as impressive as Intersil's: Researcher D L Rogers will report on a single-chip monolithic fiber-optic-receiver circuit capable of 200M-bps operation. The circuit, which generates logic outputs directly from PIN-

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photodiode inputs, achieves the broad bandwidth and sensitivity of hybrid designs, says Rogers.

A key element in this circuit's design is the use of current-mode amplification. It permits achievement of greater sensitivity and bandwidth (heretofore unobtainable in monolithic circuits) with today's advanced fiber-optic cables.

New CMOS process

In another anticipated ISSCC development, Intel will use **session XV** ("Advanced Process Technology") to formally announce its high-performance CMOS process. The firm's paper, titled "HMOS-CMOS Technology," will report on the new bulk-CMOS technology, based on the company's HMOS.

According to Intel, the process affords such features as high resistivity, a p substrate, diffused wells and 2-μm-channel-length n- and p-channel devices. Its high resistivity minimizes parasitic capacitance between the drain and source-to-substrate interface, reducing circuit delays.

Describing a test vehicle for the new technology, the Intel authors will demonstrate its use in a 4k static RAM now under development. The device, which has been fabricated, specs a typical access time of only 25 nsec and microwatt-level standby power. Intel claims the technology presents no major processing problems and is no more complicated than other NMOS processes currently in use. A spokesman maintains that this bulk-CMOS approach could someday become the dominant VLSI processing technology.

Although few details are available, one other paper slated for **session XV** appears extremely interesting. In it, researchers at NTT will report on a static bipolar 256×4 ECL RAM with typical access time of only 2.7 nsec, achieved at a power dissipation of only 550 mW. The device is being fabricated with a self-aligned polysilicon base and emitter process. Complete details will be disclosed at the show.

VLSI innovations

Session XVI ("VLSI Logic") will also include some innovative papers. For instance, in addition to applying SOS technology to RAMs (as discussed earlier), Toshiba is applying it to microprocessing. Researchers will report on a 16-bit, 12,000-gate LSI processor using this CMOS/NMOS SOS technology.

The chip features 300-nsec cycle time and 600-mW power dissipation. Architectural features include parallel-pipelined operation with four 16-bit prefetched user instructions, externally placed microprogram storage (resulting in an adaptive architecture), two 16-bit internal data bases and a 32-bit-wide interface bus. This bus communicates with external memories and I/O devices in addition to receiving microcode and status/node information.

The device employs a 16-bit barrel shifter, which performs multibit shifting of as many as 15 bits per microcycle. It also incorporates a parallel 16-bit multiplier and a binary ALU with a decimal adder/subtracter **(Fig 2)**.

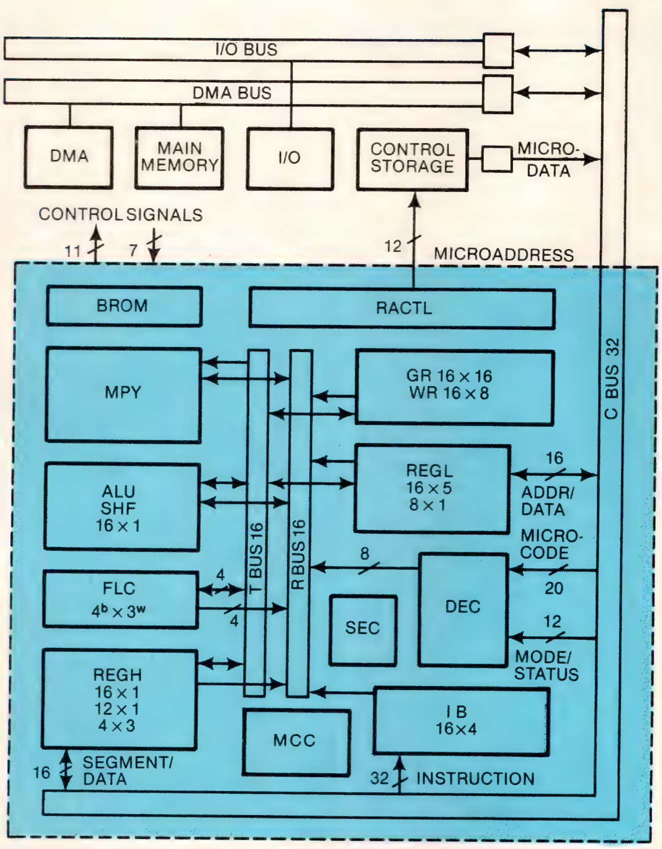

Fig 2—A 16-bit, 12,000-gate LSI processor *from Toshiba employs the firm's CMOS/SOS technology. Scheduled for discussion in ISSCC* ***session XVI,*** *the device consists of several subsystems. MCC is a memory-cycle control unit; IB consists of four 16-bit instruction buffers and autonomous instruction-fetch-control circuits; SEC is a sequence-control unit; and DEC consists of a 20-bit microcode register, a 12-bit mode register, a 12-bit status register and microcode decoders. Additionally, REGL consists of a memory-address register, an interface register, current- and advance-location counters, an instruction register and an 8-bit counter; GR/WR is a register file for users and micros; RACTL is a microaddress-control unit; and BROM stores data to distinguish whether an instruction consists of one or more than one microinstruction. Finally, MPY is a 16-bit parallel multiplier; ALU/SHF consists of a binary 16-bit ALU, a decimal adder/subtracter, a 16-bit barrel shifter and a quotient register to implement 32-bit operations; FLC is a flag-control unit; and REGH consists of a memory-data register and segment registers.*

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CHARACTERISTICS OF TOSHIBA'S 16-BIT CMOS/SOS PROCESSOR

CONTROL	MICROPROGRAM
MACHINE CYCLE	300 nSEC (TYP)
INSTRUCTION SET	151 INSTRUCTIONS
ADDRESSABLE MEMORY	16M BYTES
PREFETCH BUFFER	FOUR 16-BIT INSTRUCTIONS
TECHNOLOGY	Si-GATE CMOS/NMOS SOS
CHIP SIZE	6.66 × 7.46 mm
NUMBER OF GATES	12,000
POWER DISSIPATION	0.6W (TYP)
PACKAGE	64-PIN DIP

INSTRUCTION	TYPICAL EXECUTION TIME (μSEC)
REGISTER TO REGISTER	
ADD/SUBTRACT	0.3
MULTIPLY	1.2
DIVIDE	10.5
SHIFT (0 TO 15 BITS)	0.3
BRANCH	0.3/1.35
FLOATING POINT ADD	11.55-22.5
SUBTRACT	11.85-22.8
MULTIPLY	6.0-14.7
DIVIDE	32.85-35.25
MEMORY TO REGISTER (INDEXED)	
ADD/SUBTRACT	1.05

The instruction set consists of 151 commands, including 12 floating-point and 16 decimal ones, and the device can address as much as 16M bytes. Additional specifications appear in the **table,** which also provides instruction-execution times.

Toshiba's fabrication process fully utilizes ion implantation for threshold - voltage control and source/drain formations. A single n-type polysilicon gate structure serves in both n- and p-channel transistors with a 3.5-μm channel length. Gate-oxide thickness equals 700Å, and the device employs a highly resistive p-type 0.6-μm-thick silicon film on sapphire.

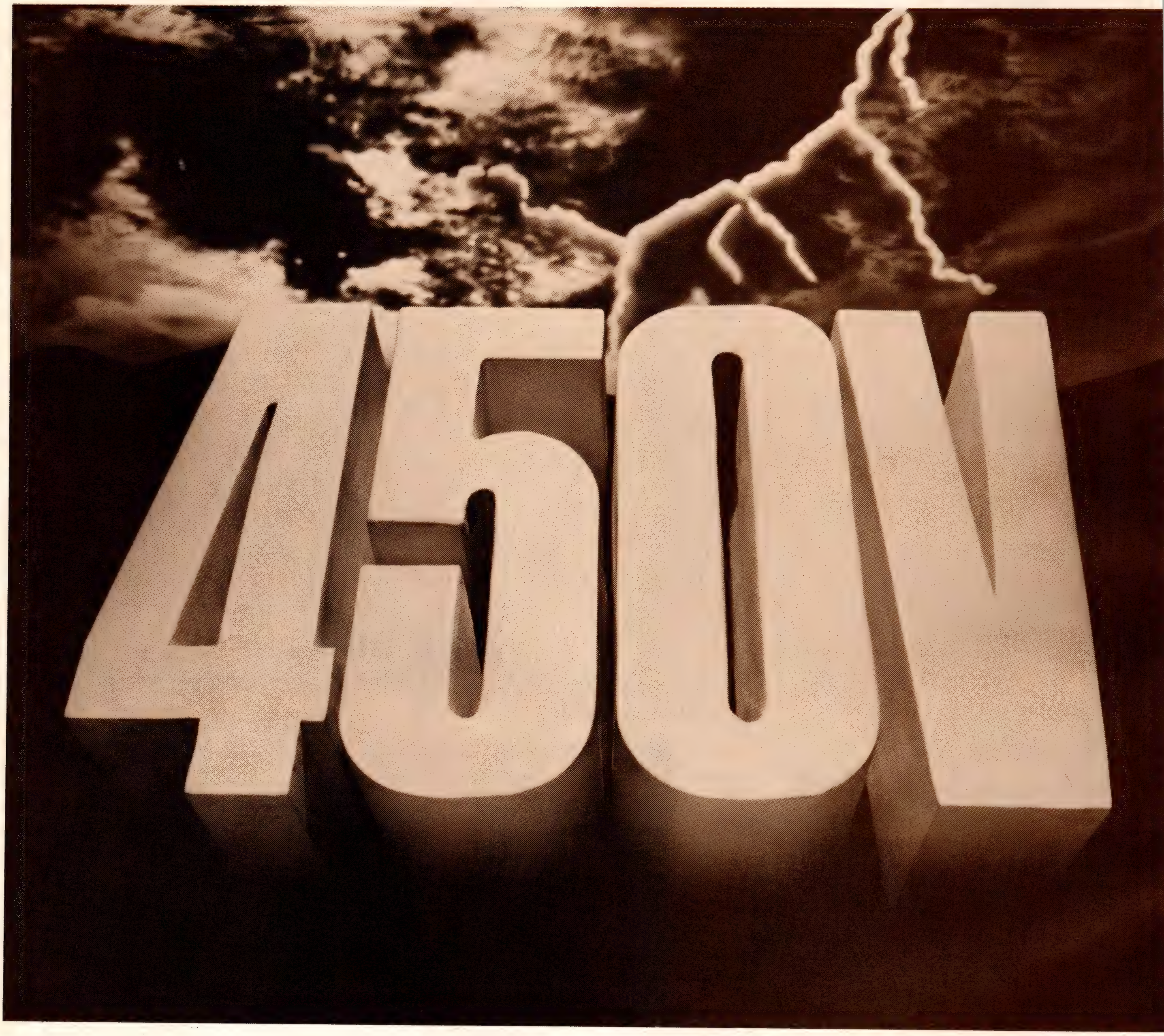
Convolver in monolithic form

Following the Toshiba paper will be one that describes a noteworthy device from TRW. In "One Micron Bipolar VLSI Convolver," the firm will describe a 16-stage unit, consisting of 16,200 devices, that operates at 30 MHz while consuming only 700 mW. It can perform 96 million additions and subtractions per second.

Convolution principles apply to many digital-signal-processing requirements, but convolver circuitry to date has been primarily fabricated with discrete devices. Typical applications for such devices have centered on military hardware, including sonar, radar and guidance systems. Although pricing information for the TRW device is not yet available, the high cost of traditional convolution circuitry now in use, in addition to the design's space-saving factors, should make it very attractive to the military establishment at any price.

Although this preview has discussed only a handful of ISSCC 81 papers, don't think they're the only important ones. Other sessions will report on advances in consumer and microwave circuits, data-acquisition systems, analog filters and oscillators. And all should prove useful to attending engineers, because the focus is on practice, not theory. **EDN**

POWER MOSFETs



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polar power transistors are no
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on chart shows why power MOS
esigns have fewer parts, smaller

	Power MOS	Power Bipolar
Switching Speed	10 ns	1 μs
Input Current	100 nA	300 mA
Secondary Breakdown	No	Yes
Drive Circuitry	Simple	Complex
Device Paralleling	Yes	No
Integral Reverse Diode	Yes	No

ize, less weight, less cooling and
igher overall reliability.

Check these specs:

- Breakdown Voltage:
  IVN6000KNT = 450V, Min.
  IVN6000KNS = 400V, Min.
  IVN6000KNR = 350V, Min.
- Switching Speed:
  10ns, Max.
- On Resistance:
  3.0Ω at 1A, Max.
- Continuous Drain Current:
  2.25A, Min.
- Peak Drain Current:
  7.5A, Min.

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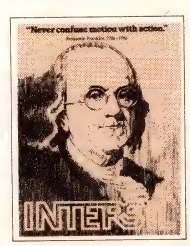

Wavelength multiplex, demultiplex devices emerge from fiber-optic research

Tom Ormond, Senior Editor

Wavelength-division multiplexing for fiber-optic systems is emerging from the laboratory; designers have advanced beyond the feasibility-demonstration stage and are now developing components that suit specific system requirements. And, points out one expert, they are finding that passive multiplexers and demultiplexers require different design details, even though one device can theoretically perform the two functions.

W John Tomlinson, member of the technical staff at Bell Laboratories (Holmdel, NJ), points out that wavelength-division multiplexing has sparked high interest because it dramatically increases information capacity. And he adds that in addition to the usual factors (cost, availability, reliability), three basic criteria help designers evaluate a multiplexer/demultiplexer pair from a system point of view—insertion loss, channel width and crosstalk.

Designers generally agree that the first quantity must be less than a few decibels at each end of the pair—the lower the better. Additionally, laser diodes' wavelength reproducibility and stability require channel-bandwidth requirements as high as several hundred angstroms; LED sources call for even larger channel widths. Finally, although crosstalk-level specs vary widely, −30 dB usually proves more than adequate.

But Tomlinson observes that in most cases, LED and diode sources don't emit much power outside their peak emission wavelengths, so crosstalk rejection is relatively unimportant for a multiplexer. (It is important, though, to match the source's output-mode pattern to that of the transmission fiber.) A demultiplexer, on the other hand, must meet system-crosstalk requirements because detectors are usually sensitive at each channel's wavelength.

Choose two component classes

Two types of components serve multiplexing and demultiplexing functions: angularly dispersive and filter devices. (Investigators have proposed some multilayer semiconductor detectors, and Tomlinson says that some of these active devices could ultimately prove useful in specialized applications. However, they still require further research.)

Angularly dispersive devices routinely provide crosstalk levels between −20 and −30 dB, and they are well suited to parallel operation, according to Tomlinson. Most basic designs **(Fig 1)** can separate as many channels as required with one grating or prism. (Although separate lenses are shown for input and output in **Fig 1,** a single device satisfies both functions in many designs.)

In operation, the input lens collimates the light from the input fiber for passage through the angularly dispersive element to the output lens, which focuses the different-wavelength beams onto the various output fibers. With a monochromatic input signal, this optical system forms an image of the input fiber at some position on the output-fiber array. A wavelength scan of the input signal moves this image along the array; thus, the input and output fibers' mode structures determine the shape of the design's response curves.

Angularly dispersive devices will prove the best choice for demultiplexing applications, claims Tomlinson, because they have low crosstalk and can exhibit relatively wide flat-topped channel bandwidths when used with large-core output fibers. They should demultiplex multimode and single-mode signals equally well.

These devices will also satisfy multimode-signal multiplexing ap-

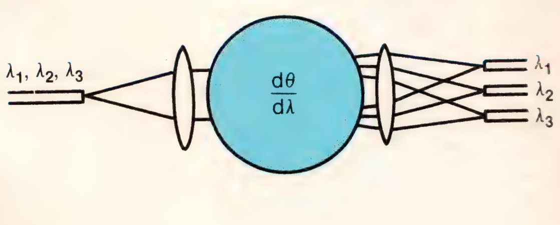

Fig 1—Because they exhibit low crosstalk levels *and relatively wide channel bandwidths, angularly dispersive devices are well suited to fiber-optic demultiplexing applications. They should accommodate multimode and single-mode signals equally well.*

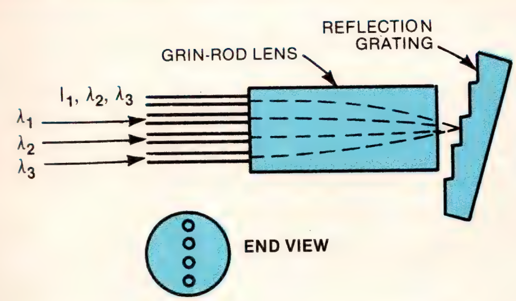

Fig 2—Multichannel demultiplexing's no problem *for angularly dispersive devices. With only a single graded-refractive-index rod (GRIN-rod) lens and grating, you can separate as many channels as required.*

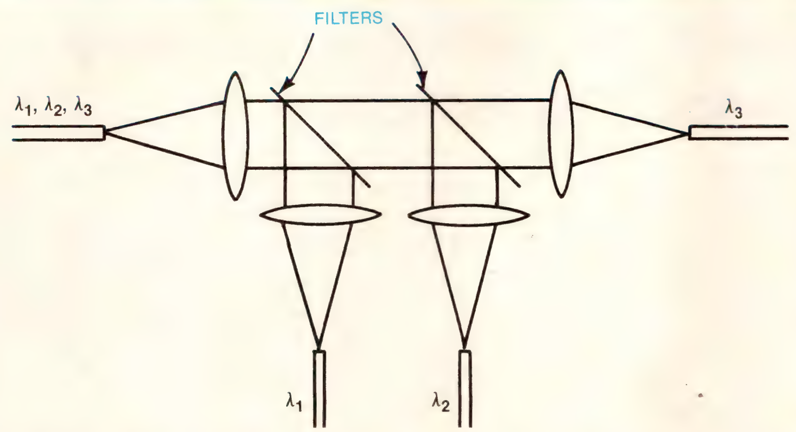

Fig 3—Most suited to the multiplexing function, *filter devices employ multilayer dielectric films as filter elements.*

plications, although it will be difficult to attain the necessary channel bandwidths with them. On the other hand, they're unlikely to ever prove useful for multiplexing single-mode signals, says Tomlinson, who reviewed the state of the art in wavelength multiplexing and demultiplexing at the FOC '80 show in San Francisco.

Most angularly dispersive devices use a grating/lens combination **(Fig 2)** and can be packaged as a solid assembly. Insertion losses are typically in the 1- to 3-dB range, and the grating devices readily adapt for use in any wavelength range. The graded-refractive-index rod (GRIN-rod) lens depicted in **Fig 2** is only one design; others use conventional lenses or a concave grating.

Filters suit MUXing

In a basic filter device **(Fig 3)**, the elements are multilayer dielectric films with a high reflectivity for one or more channels and a low reflectivity for the rest. Characteristically, says Tomlinson, they are most suited to serial operation: In most cases, each additional channel requires another lens and filter, so multichannel filter-type devices are complex.

Filter-type devices also usually have higher crosstalk levels than angularly dispersive components because fabricating filters with sharp cutoffs remains difficult. On the positive side, their passband shapes don't depend on fiber characteristics—you can use a set of filters providing the desired wavelength characteristic with almost any type of fiber, says Tomlinson.

Considering these characteristics, filter devices are most suited to multiplexing—their crosstalk requirements aren't too stringent, and no channel-bandwidth degradation occurs when matching a filter's output fiber to the transmission fiber.

And in some cases—2-channel systems with widely separated (0.8 and 1.3 μm) channels—filter devices could prove the best choice for both multiplexing and demultiplexing, according to Tomlinson. In fact, he reports that 2-channel filter devices have already provided simultaneous 2-way transmission over a single fiber. (Additional filtering was necessary to reduce crosstalk to acceptable levels.)

Currently, filter devices also appear to offer the only feasible approach for multiplexing single-mode signals. By mounting all the lenses on axis, one basic design for this purpose **(Fig 4)** eliminates coupling losses from off-axis aberrations.

IC optics still experimental

Examining potential developments, Tomlinson notes that single-mode-signal multiplexing schemes using various integrated optical filters are currently under investigation. However, obtaining wide channel bandwidths in these integrated components remains difficult.

Additionally, no technique is yet available to provide low-loss coupling between the planar integrated optics and a single-mode fiber. But modern IC production techniques could readily provide the solution to this coupling problem, says Tomlinson, so the future looks bright for integrated optical-fiber devices. **EDN**

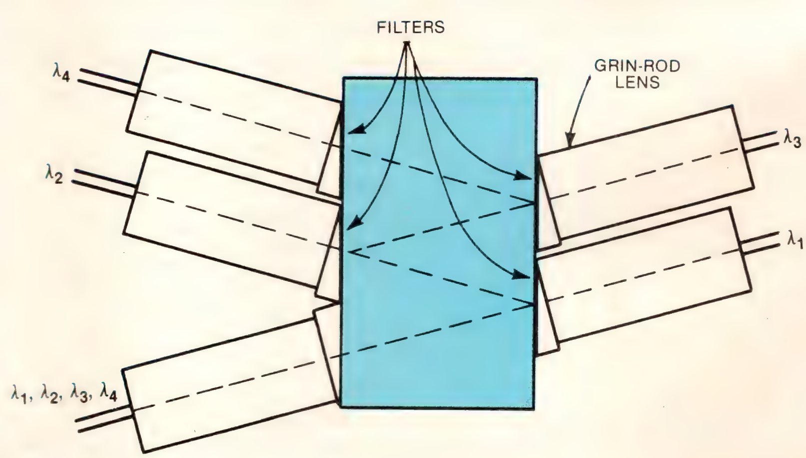

Fig 4—To accommodate single-mode signals, *this filter device mounts all lenses on its axis, eliminating coupling losses from off-axis aberrations.*

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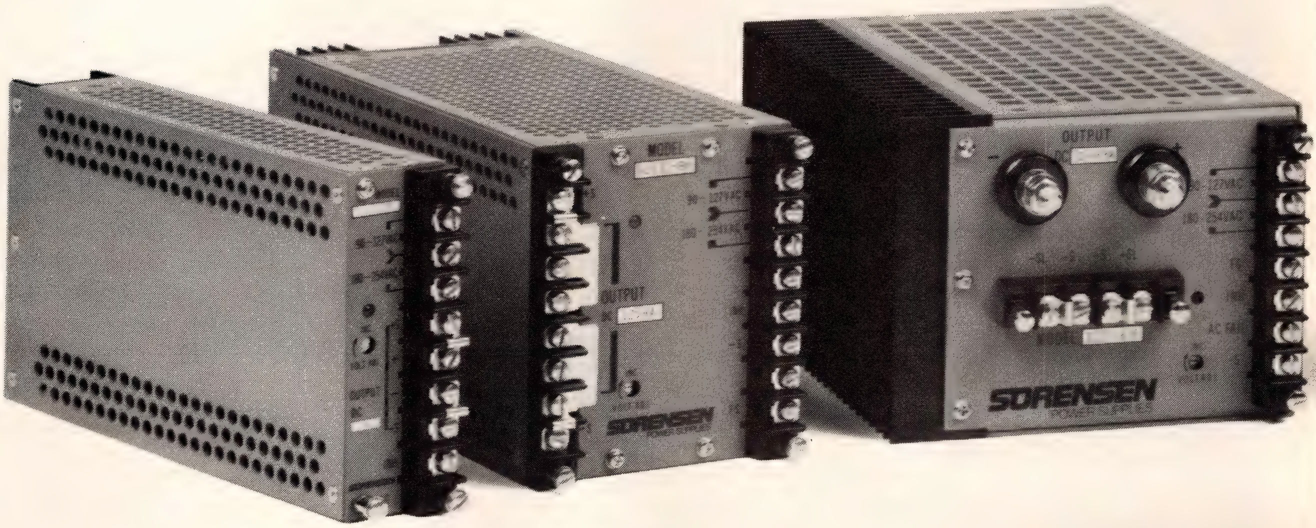

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9	SLC9-3.3B	3.3A	180
9	SLC9-6B	6A	240
12	SLC12-2.5B	2.5A	$180
12	SLC12-4.5B	4.5A	240
12	SLC12-8B	8A	345
12	SLC12-12B	12A	385
12	SLC12-16.7B	16.7A	445
12	SLC12-25B	25A	550
15	SLC15-2B	2A	$180
15	SLC15-3.6B	3.6A	240
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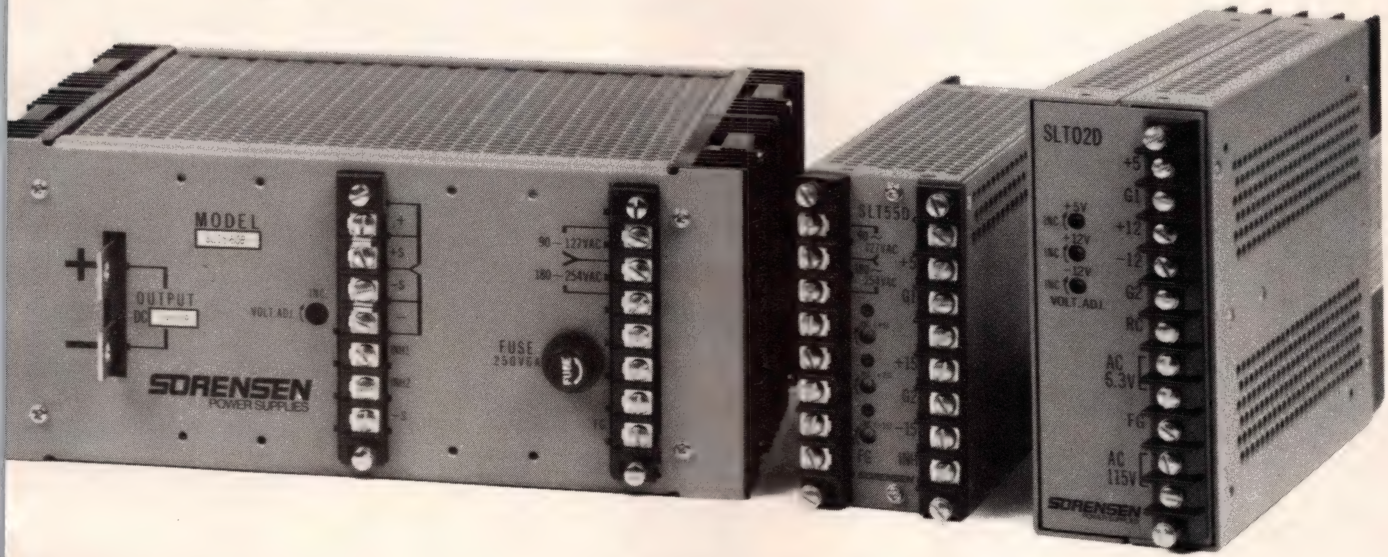

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20	SLC20-5B	5A	345
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20	SLC20-10B	10A	445

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24	SLC24-4B	4A	345
24	SLC24-6B	6A	385
24	SLC24-8.3B	8.3A	445
24	SLC24-12.5B	12.5A	550
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+5V, +15V, −15V	SLT-55D	5A, 0.5A, 0.5A	310
+5V, +12V, −12V	SLT-02D	10A, 1A, 1A	380
+5V, +12V, −5V	SLT-025	10A, 1A, 1A	380
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The MBM-1 incorporates two input ports: a serial RS-232C unit permitting data rates ranging from 110 to 19,200 baud and an 8-bit parallel port supporting 2k-bytes/sec transfer rates. Its recording format permits writing of special control characters differentiable from other 8-bit binary inputs because each byte is recorded in a 9-bit code.

Using two 64k-bit bubble-memory cassettes, *Model MBM-1 solves data-logger reliability problems in harsh environments.*

CMOS logic

The data logger employs CMOS logic that supports control instructions from a host processor or those generated from the front panel. The front-panel functions include Write (sets the Record mode), Read (sets the Read mode), Read Off (stops a read operation), Erase (removes all data from cassette memory and puts a start mark at the first available location), Start (initializes a cassette at prerecorded start mark for either reading or writing), File (puts a byte in a cassette to identify a specific file for later search), Page (moves the memory pointer to the next logical page in the 64k-bit memory map) and Reset (reinitializes the system).

The unit suits industrial-control applications requiring small amounts of memory but high reliability. According to the manufacturer, it finds use in environments subject to dust, chemicals or drastic temperature changes.

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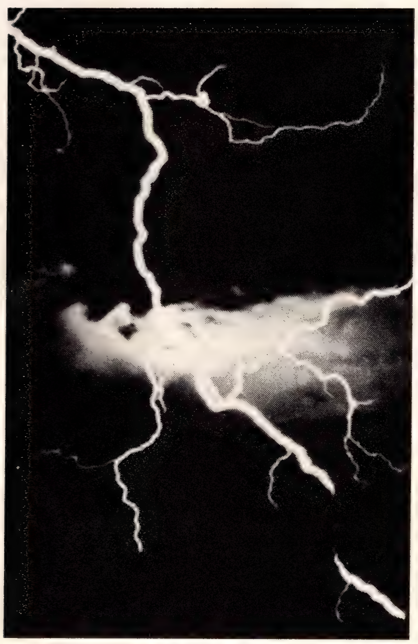
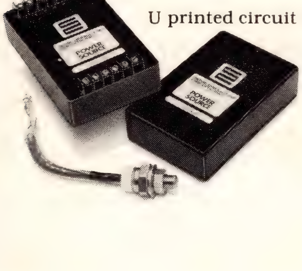


CU chassis mount

U printed circuit mount



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Editor's Choice: New Products

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- Ripple and switching spikes
- Temperature variations from 0 to 50°C
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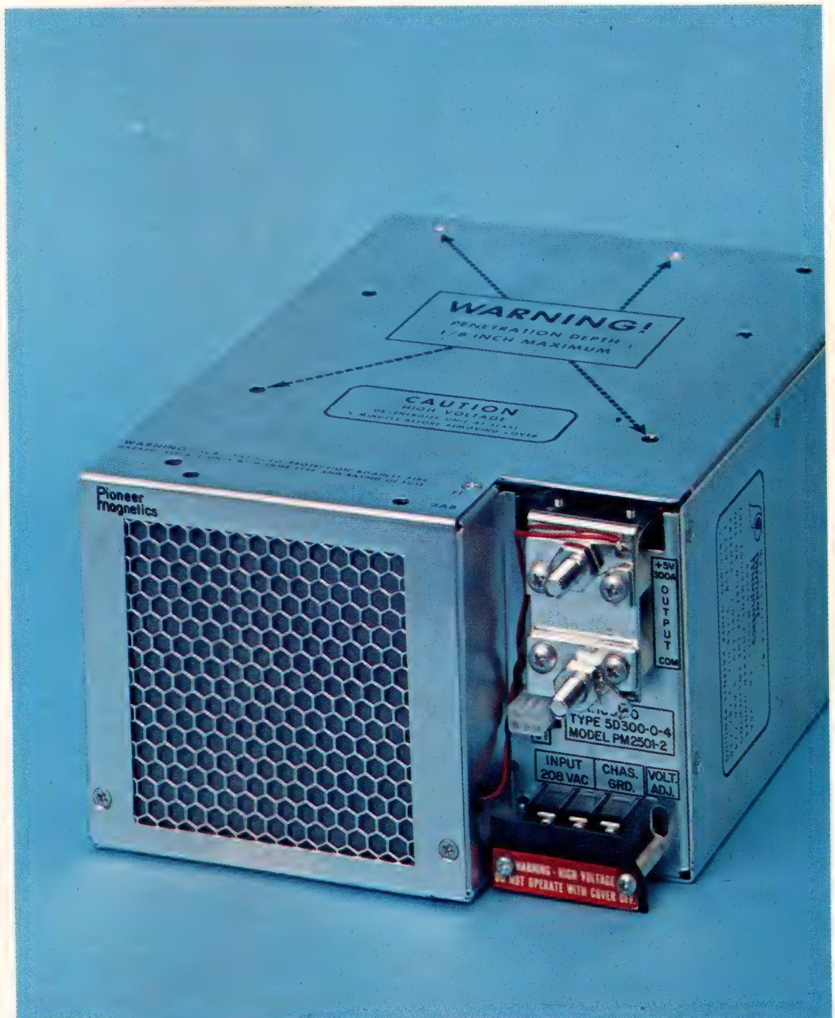

In a package that formerly provided 1000W, *Model PM 2501 delivers 1500W. The 20-lb switcher comes with foldback and current limiting and furnishes a 20-msec hold-up period.*

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The supply's current-limiting circuitry initiates foldback when the switcher delivers 100 to 120% of its full load current. The output recovers automatically from overcurrent shutdown after you remove the load fault. Overvoltage-protection circuits ensure that your system will never see more than 125% (±10%) of the rated output voltage.

If the input power quits completely, the PM 2501 provides 20 msec of hold-up time. An optional power-fail circuit allows the supply to notify the system immediately.

Other options include logic inhibit and enable, crowbar, remote programming, automatic paralleling and a Power Good signal. And if necessary, the manufacturer can tailor the supply to meet unusual requirements.

The standard supply weighs 20 lbs and comes with an LC EMI-suppression filter. Adding an external filter allows the unit to meet VDE 0871B specs.

A 5V, 300A model costs $1000. Delivery, 6 to 8 wks ARO.

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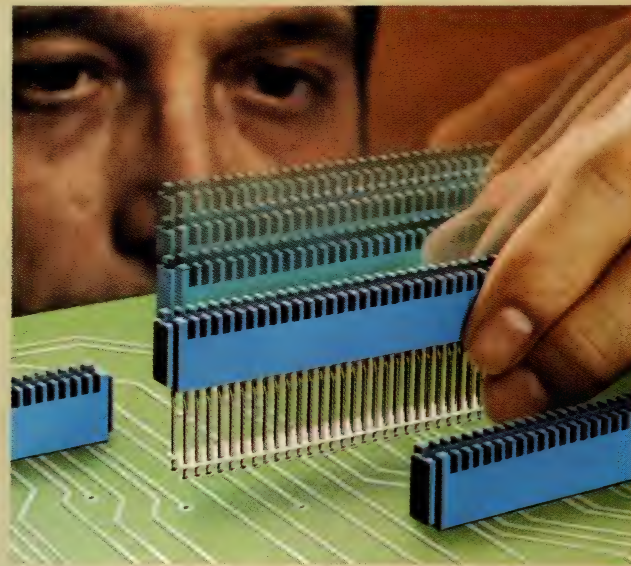

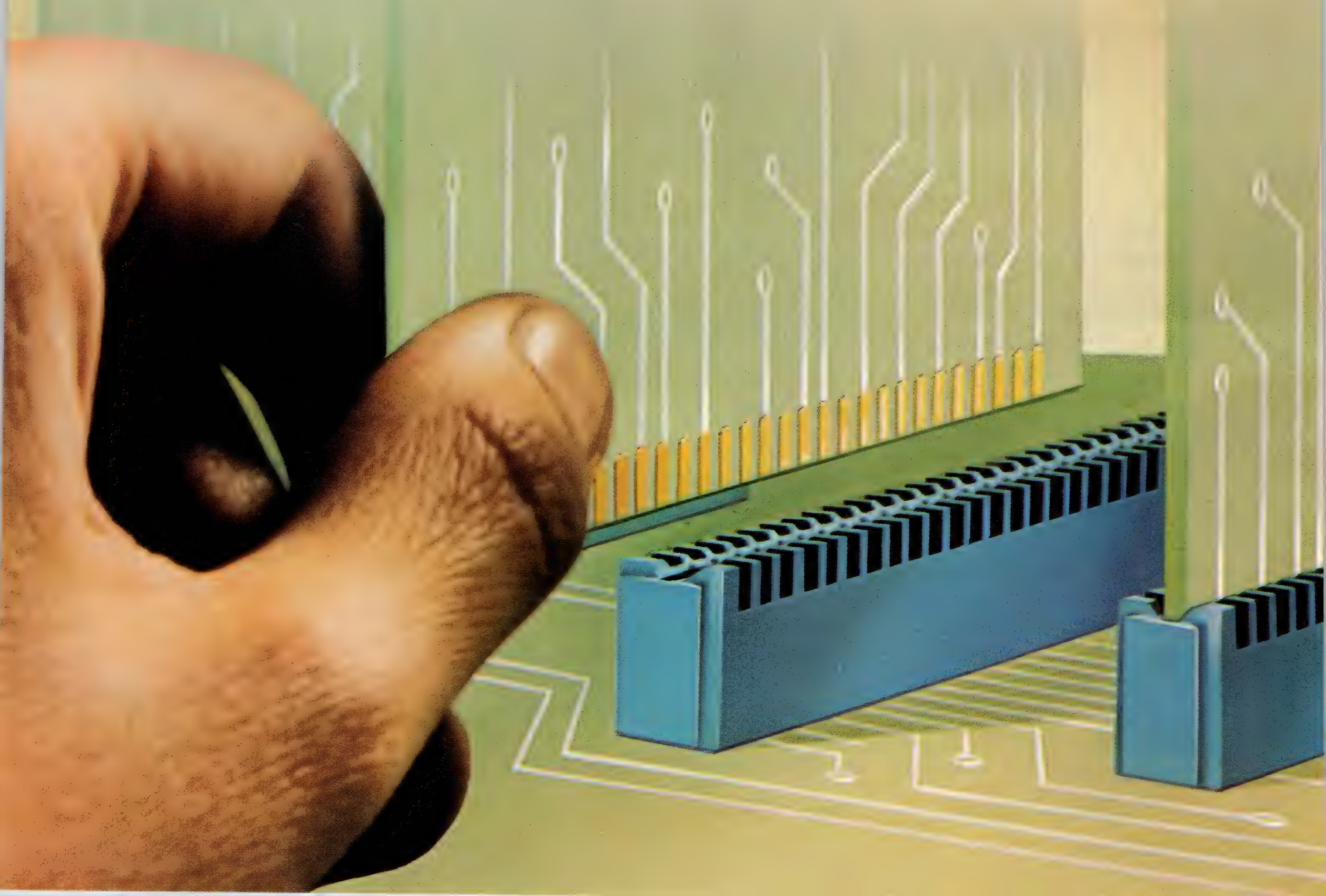

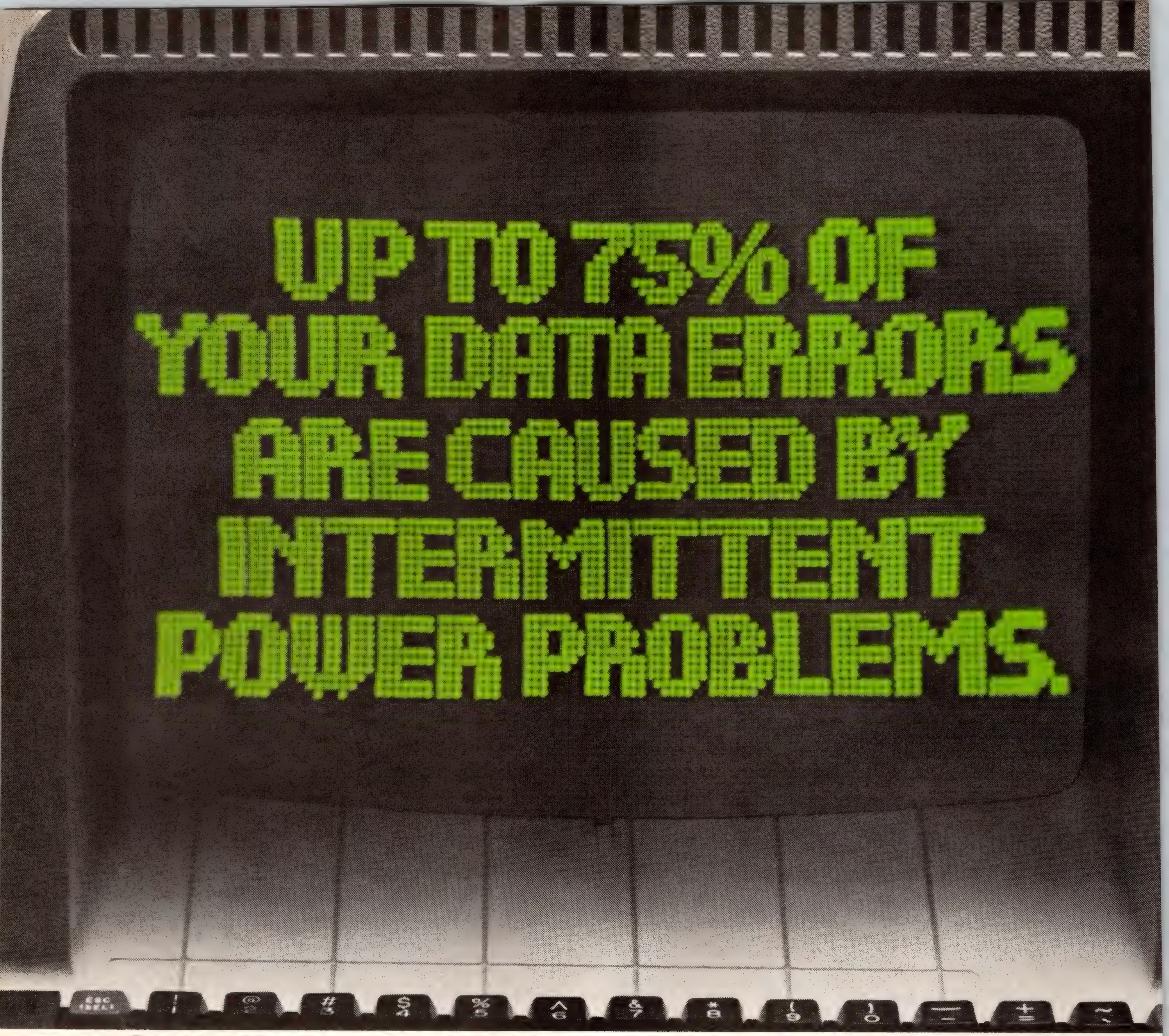

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Program calculates stock-options tax

Ed Oxner
Siliconix Inc, Santa Clara, CA

If your company's stock-purchase plan offers you the opportunity to buy shares at less than the fair market price, you could be subject to a preferential tax. But whether or not you were aware that purchasing shares under either a qualified or restricted stock-option plan poses a potential tax liability, you might find this program for the HP-67 calculator useful.

Under current IRS rulings, the preferential tax is based on a simple formula: If the total cost of the shares purchased at your option price is more than $10,000 under the fair market price for a like number of shares *at the time of your purchase*, you must pay a tax on the amount exceeding $10,000. The tax rate is now 15%. (Remember, too, that when you sell the stock you must also consider your tax liability.)

The program (**figure**) offers two types of solutions: You can ask how many shares you can buy to avoid liability for the tax, or you can ask how much tax you'll owe on the number of shares you wish to purchase. Of course, the input figures you use might not be the final figures your company uses when it gets around to placing your order, but they should be close.

Should the IRS modify its tax structure, the program will still prove useful because both the allowable amount and the tax rate are variables.

To use the program, enter:

- A=Your option price in decimal dollars; for example: $3.75
- B=Government allowance, currently $10,000
- C=Preferential-tax rate in percent, currently 15%
- D=Fair market price per share in decimal dollars; for example: $16.375 (16⅜ per share)
- E=If you're asking how many tax-free shares you can purchase, just hit the key. On the other hand, if you want to know your tax liability, enter the number of shares you wish to buy.

The program produces one of two types of answers. If you're asking how many shares you can buy without incurring a tax, a whole number will appear. For instance, the example figures lead to an answer of 791 tax-free shares. If you're asking for your tax liability on a specified number of shares, on the other hand, one of two numbers will appear. For a number of shares less than the maximum (791 in this example), you'll get the number of shares allowable with no tax liability. For a request greater than what is tax free, a decimal-dollar figure results. For example, the tax liability on 900 shares using the example figures is $204.38. **EDN**

STEP	KEY ENTRY	KEY CODE	STEP	KEY ENTRY	KEY CODE	STEP	KEY ENTRY	KEY CODE
001	f LBL A	31 25 11	025	RCL 8	34 08	049	STO+3	33 61 03
002	STO A	33 11	026	h RTN	35 22	050	GTO (i)	22 24
003	h RTN	35 22	027	f LBL 1	31 25 01	051	f LBL 4	31 25 04
004	f LBL B	31 25 12	028	f GSB 2	31 22 02	052	RCL 3	34 03
005	STO B	33 12	029	h RTN	35 22	053	h RTN	35 22
006	h RTN	35 22	030	f LBL 2	31 25 02	054	f LBL 6	31 25 06
007	f LBL C	31 25 13	031	1	01	055	RCL D	34 14
008	STO C	33 13	032	5	05	056	RCL 9	34 09
009	h RTN	35 22	033	CHS	42	057	X	71
010	f LBL D	31 25 14	034	h ST I	35 33	058	STO 8	33 08
011	STO D	33 14	035	RCL 3	34 03	059	RCL A	34 11
012	h RTN	35 22	036	RCL A	34 11	060	RCL 9	34 09
013	f LBL E	31 25 15	037	X	71	061	X	71
014	STO 3	33 03	038	RCL B	34 12	062	STO-8	35 51 08
015	STO 9	33 09	039	+	61	063	RCL 8	34 08
016	f x=Ø ?	31 51	040	RCL D	34 14	064	RCL B	34 12
017	GTO 1	22 01	041	÷	81	065	—	51
018	f GSB 2	31 22 02	042	f INT	31 83	066	ENTER	41
019	STO 8	33 08	043	RCL 3	34 03	067	RCL C	34 13
020	RCL 9	34 09	044	—	51	068	f %	31 82
021	—	51	045	STO 5	33 05	069	DSP 2	23 02
022	f x<Ø ?	31 71	046	f x=Ø ?	31 51	070	h RTN	35 22
023	GTO 6	22 06	047	GTO 4	22 04	071	R/S	84
024	DSP Ø	23 00	048	RCL 5	34 05			

Use your HP-67 to calculate the tax liability *when you take advantage of your company's stock-option plan.*

Interrogation tells μP which boards are present

N D Mackintosh
Burroughs Corp, Westlake Village, CA

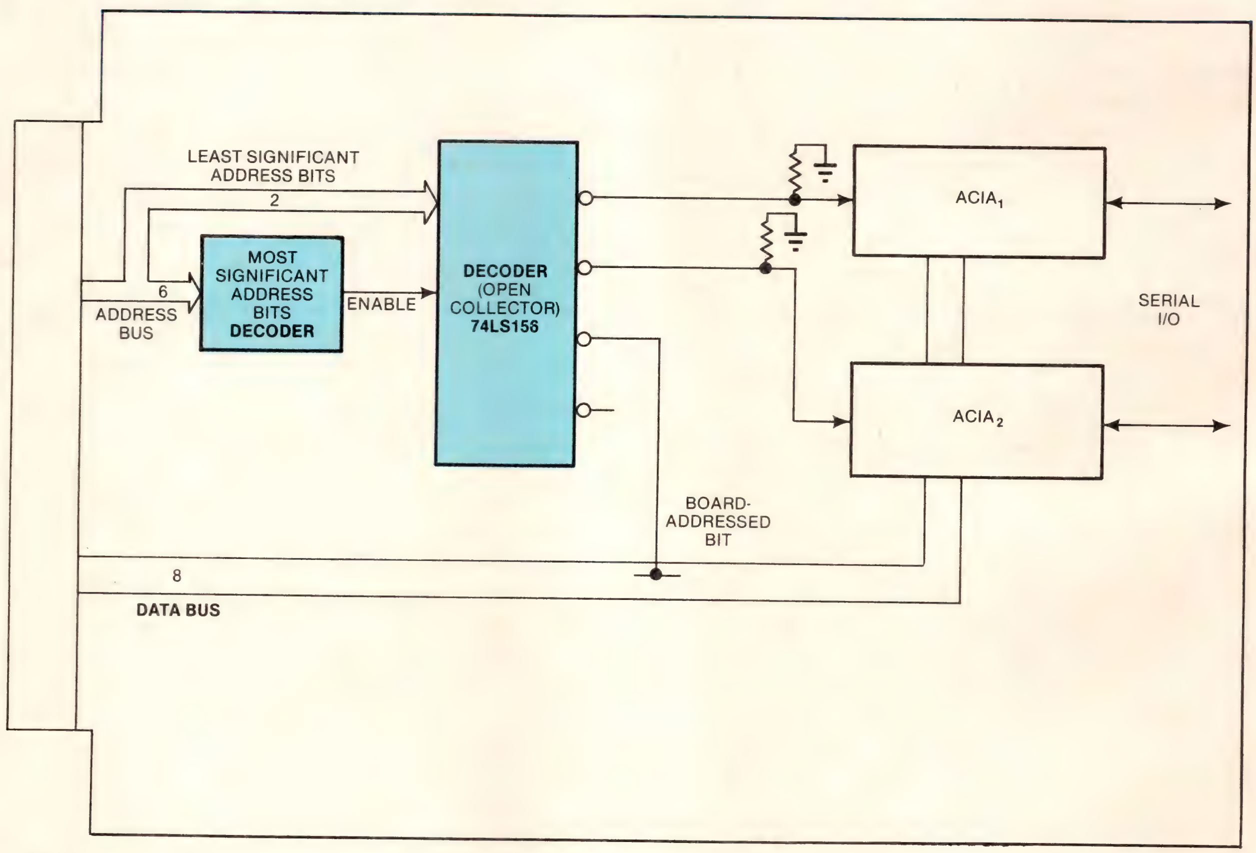
One of the microprocessor's greatest assets is its versatility. And to take advantage of this feature, more and more systems are being designed in a rack format, in which several card positions suit any number of different cards. As a result, the μP must be able to determine which cards are plugged in and which positions they occupy.

The simple answer to this problem centers on switches mounted on a subpanel. But this approach ignores situations in which a board is removed for repair while the rest of the system keeps running. A more elegant solution provides the μP with the ability to interrogate each board to determine its type. Because all boards already have address decoding, the task proves simple and might require adding no hardware at all. The required added function consists of one extra address—a board address (rather than the function address already used).

At power-on or at regular intervals, the μP performs an attendance check, sending out the address reserved for each board position and determining what comes back on the data bus. When the μP addresses a given board and no board is present, the data bus's pull-up resistors cause the bus to read all ONEs.

If a board is in a slot, it must impose a ZERO on one or more of the data-bus lines to indicate its presence. Each board should have a unique pattern that indicates its type; by toggling only one bit, your system can identify as many as eight types, and using all eight bits provides identification of 255.

The **figure** illustrates a simple open-collector decoder that can directly indicate a board's presence by manipulating a bit on the data bus. **EDN**



Adding address decoding for a second address *that identifies each board and its position lets a μP take roll call in a multiboard system.*

EDN Software Note #62

Program tests 9900 system's memory

Ralph Tenney
George Goode & Associates Inc, Dallas, TX

The program shown in the **figure** helps maintain several TM 990/302 software-development systems. Produced with the 302's resident assembler, the procedure begins with a simple functional test—clear all memory under test. A walking-ONEs test follows; this procedure involves successively writing a ONE to each bit in a 16-bit memory word, beginning with 8000_H, then leaving the value 0001_H in each word. The program tests the write operation at each bit location before moving to the next one. The final test writes all ONEs (FFFF) to a location, then checks the remaining locations for possible changes.

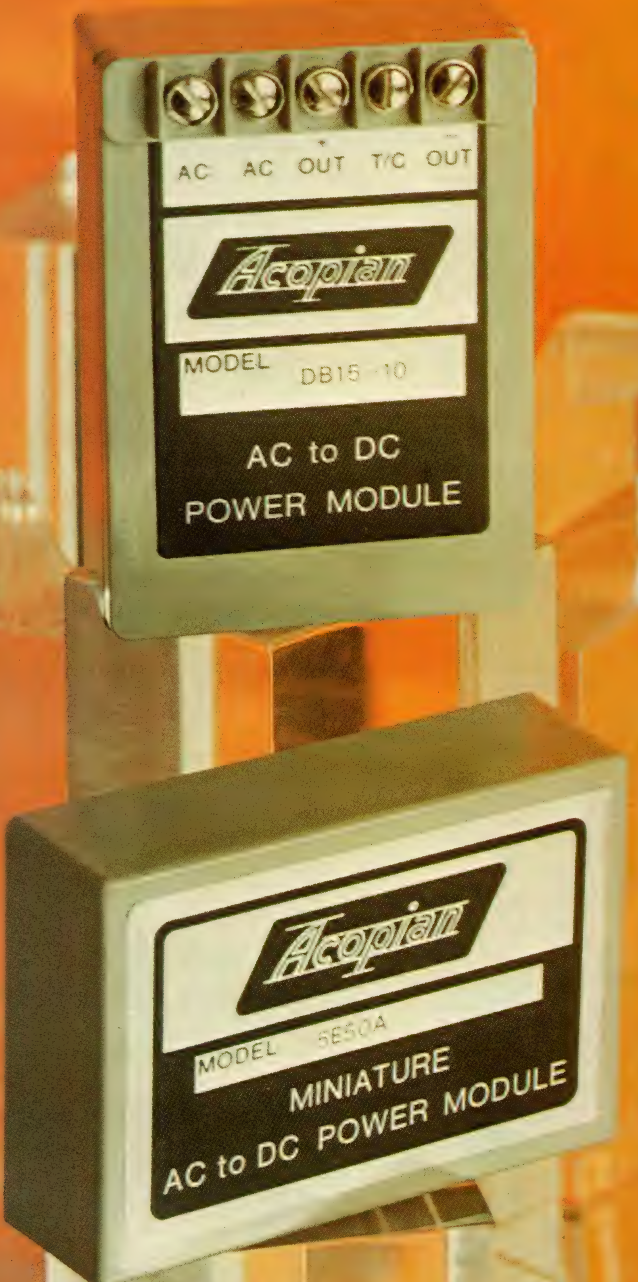
The procedure involves three error flags and error messages. An error stops the test; you must then check the offending location with the debugging monitor to determine whether the error is soft or hard. For a hard error, you must change the test boundaries to exclude the affected location; a soft error only requires starting the test from scratch.

The test isn't rapid; you'll need approximately 5 min to perform one iteration over 3000_H locations. Each successful pass prints "OK" on the terminal. Thus, you can leave the system in the Test mode for long periods of time and know how many iterations it has made. At the end of a complete test, one "OK" will have been printed for each program iteration, followed by "AA." Failure to pass the memory-clear test produces only "AA," while failure of the walking-ONEs test produces "BB." If the all-ONEs test fails, you'll see "FF." **EDN**

```
          0000 R0     EQU   0
          0001 R1     EQU   1
          0002 R2     EQU   2
          0003 R3     EQU   3
          0004 R4     EQU   4
          0005 R5     EQU   5
          0006 R6     EQU   6
          0007 R7     EQU   7
          0008 R8     EQU   8
          0009 R9     EQU   9
          000A R10    EQU   10
          000B R11    EQU   11
          000C R12    EQU   12
          000D R13    EQU   13
          000E R14    EQU   14
          000F R15    EQU   15
     0000        *THIS PROGRAM IS A MEMORY TEST WHICH CLEARS THE MEMORY
     0000        *AREA UNDER TEST AND CHECKS THE RESULT.  THEN A WALKING
     0000        *BIT TEST IS PERFORMED, FOLLOWED BY WRITING ALL ONES TO
     0000        *ONE LOCATION, TESTING THE WHOLE MEMORY, THEN WRITING
     0000        *TO THE NEXT LOCATION.  ENTER THE STARTING ADDRESS IN
     0000        *R1, THE ENDING ADDRESS IN R2, AND THE NUMBER OF TEST
     0000        *ITERATIONS IN R7.
                      IDT   'MTST'
     3E00             AORG  >3E00
     3E00 02E0 ST0    LWPI  WS
     3E02 3E90
     3E04 C101 ST     MOV   R1,R4          GET STARTING ADDRESS
     3E06 04C5        CLR   R5             SET UP STARTING PATTERN
     3E08 0208        LI    R8,1           SET UP A TEST PATTERN
     3E0A 0001
     3E0C C505 OUT1   MOV   R5,*R4         AND WRITE IT TO MEMORY
     3E0E 8084        C     R4,R2          TEST FOR END ADDRESS
     3E10 1304        JEQ   TST2           IF END, START NEXT TEST
     3E12 8174        C     *R4+,R5        CORRECT MEMORY ENTRY?
     3E14 1626        JNE   ERR0           REPORT THE ERROR
     3E16 8084        C     R4,R2          LAST LOCATION?
     3E18 12F9        JLE   OUT1           IF NOT, GO AGAIN
     3E1A C101 TST2   MOV   R1,R4          GET STARTING ADDRESS
     3E1C 0205        LI    R5,>8000       SET UP WALKING BIT START PATTERN
     3E1E 8000
     3E20 C505 OUT2   MOV   R5,*R4         AND WRITE IT TO MEMORY
     3E22 8084        C     R4,R2          TEST FOR END ADDRESS
     3E24 1308        JEQ   TST3           IF END, START NEXT TEST
     3E26 8154        C     *R4,R5         CHECK FOR CORRECT MEMORY CONTENTS
     3E28 161F        JNE   ERR1           REPORT ERROR
     3E2A 0B15        SRC   R5,1           WALK THE BIT
     3E2C 0285        CI    R5,>8000       TEST FOR FULL SHIFT
     3E2E 8000
     3E30 16F7        JNE   OUT2           IF NOT DONE, FINISH UP
     3E32 05C4        INCT  R4             BEGIN TESTING
     3E34 10F5        JMP   OUT2           ON NEXT LOCATION
     3E36 C101 TST3   MOV   R1,R4          GET STARTING ADDRESS AGAIN
     3E38 0705        SETO  R5             SET PATTERN TO ALL ONES
     3E3A C505 OUT3   MOV   R5,*R4         WRITE IT IN MEMORY
     3E3C C182        MOV   R2,R6          SAVE END ADDRESS
     3E3E 6184        S     R4,R6          FIND OUT HOW MANY LOCATIONS LEFT
     3E40 C186        MOV   R6,R6          ANY UNTESTED LOCATION?
     3E42 1309        JEQ   REPT           IF NOT, CLEAN UP AND GO HOME
     3E44 8154        C     *R4,R5         TEST FOR CORRENT MEMORY ENTRY
     3E46 1613        JNE   ERRF           REPORT ANY ERRORS
     3E48 C244        MOV   R4,R9          SAVE CURRENT TEST POINTER
     3E4A 8219 CPAT   C     *R9,R8         TEST FOR CHANGED PATTERN
     3E4C 0649        DECT  R9             BUMP TO NEXT LOCATION TO BE CHECKE
     3E4E 1BFD        JH    CPAT           CONTINUE TESTING UNTIL DONE
     3E50 05C4        INCT  R4             BUMP POINTER TO NEXT LOCATION
     3E52 8084        C     R4,R2          LAST LOCATION?
     3E54 12F2        JLE   OUT3           REPEAT UNTIL DONE
     3E56 0200 REPT   LI    R0,MSOK        GET CHECK MESSAGE
     3E58 3E7C
     3E5A 0420        BLWP  @>E01C         AND OUTPUT IT
     3E5C E01C
     3E5E 0607        DEC   R7             BUMP THE COUNTER
     3E60 1BD1        JH    ST             AND REPEAT TESTS UNTIL DONE
     3E62 0200 ERR0   LI    R0,MSSA        GET FIRST ERROR FLAG
     3E64 3E81
     3E66 1006        JMP   EXIT           AND PRINT IT
     3E68 0200 ERR1   LI    R0,MSSB        GET SECOND ERROR FLAG
     3E6A 3E86
     3E6C 1003        JMP   EXIT           AND PRINT IT
     3E6E 0200 ERRF   LI    R0,MSSF        GET THIRD ERROR FLAG
     3E70 3E8B
     3E72 1000        JMP   EXIT           AND PRINT IT
     3E74 0420 EXIT   BLWP  @>E01C         ISSUE STATUS
     3E76 E01C
     3E78 0420        BLWP  @>E000         AND GO HOME
     3E7A E000
     3E7C 4F4B MSOK   BYTE  >4F,>4B,>0D,>0A
     3E7E 0D0A
     3E80 0000        BYTE  0
     3E81 4141 MSSA   BYTE  >41,>41,>0D,>0A
     3E83 0D0A
     3E85 0000        BYTE  0
     3E86 4242 MSSB   BYTE  >42,>42,>0D,>0A
     3E88 0D0A
     3E8A 0000        BYTE  0
     3E8B 4646 MSSF   BYTE  >46,>46,>0D,>0A
     3E8D 0D0A
     3E8F 0000        BYTE  0
     3E90      WS     BSS   32
          3E00        END   ST0            STOP ASSEMBLY AND LOAD PC
ERRORS=0
```

Make three specific memory checks *on a TM 990/302 system with this diagnostic program.*

MINIATURIZED POWER SUPPLIES



For Logic and Op Amps

With Screw Terminals

Nominal Output Voltage	Output Current Amps.	Regulation Load ±%	Regulation Line ±%	Ripple mv RMS	Price	Model	Case Size
5	.500	.15	.05	1	$ 55	5EB50	EB-10
5	1.0	.25	.05	1	75	5EB100	EB-13
5	1.5	.35	.1	1	105	5EB150	EB-13
5	2.0	.25	.05	1	115	5EB200	EB-20
5	2.5	.25	.05	1	130	5EB250	EB-20
±12	.100	.05	.05	1	55	DB12-10	EB-10
±12	.150	.05	.05	1	65	DB12-15	EB-10
±12	.200	.05	.05	1	75	DB12-20	EB-10
±12	.300	.05	.05	1	105	DB12-30	EB-13
±12	.350	.05	.05	1	110	DB12-35	EB-13
±12	.500	.1	.05	1	135	DB12-50	EB-20
±15	.100	.05	.05	1	55	DB15-10	EB-10
±15	.150	.05	.05	1	65	DB15-15	EB-10
±15	.200	.05	.05	1	75	DB15-20	EB-10
±15	.300	.05	.05	1	105	DB15-30	EB-13
±15	.350	.05	.05	1	110	DB15-35	EB-13
±15	.500	.1	.05	1	135	DB15-50	EB-20

PCB Mounting

Nominal Output Voltage	Output Current Amps.	Regulation Load ±%	Regulation Line ±%	Ripple mv RMS	Price	Model	Case Size
5	.250	.05	.05	0.5	$ 39	5E25	ES-10
5	.500	.1	.05	1	49	5E50A	EL-10
5	1.0	.2	.05	1	69	5E100	EL-13
5	1.5	.3	.1	1	98	5E150	EL-13
5	2.0	.15	.05	1	110	5E200	EL-20
5	2.5	.15	.05	1	125	5E250	EL-20
±12	.025	.1	.05	1	24	D12-03	ES-10
±12	.050	.1	.05	1	39	D12-05	ES-10
±12	.100	.05	.05	1	49	D12-10A	EL-10
±12	.150	.05	.05	1	59	D12-15A	EL-10
±12	.200	.05	.05	1	69	D12-20	EL-10
±12	.300	.05	.05	1	98	D12-30	EL-13
±12	.350	.05	.05	1	105	D12-35	EL-13
±12	.500	.1	.05	1	130	D12-50	EL-20
±15	.025	.1	.05	1	24	D15-03	ES-10
±15	.050	.1	.05	1	39	D15-05	ES-10
±15	.100	.05	.05	1	49	D15-10A	EL-10
±15	.150	.05	.05	1	59	D15-15A	EL-10
±15	.200	.05	.05	1	69	D15-20	EL-10
±15	.300	.05	.05	1	98	D15-30	EL-13
±15	.350	.05	.05	1	105	D15-35	EL-13
±15	.500	.1	.05	1	130	D15-50	EL-20

Input Voltage: 105-125 Vac, 47 to 420 Hz, single phase.

Output Voltage Setting: Single output models are factory preset to within ±2% of nominal output voltage, and may be more precisely trimmed to the nominal voltage rating with an external trim resistor. Dual models are set to within ±1% of their nominal ratings, and are not trimable.

Polarity: Either positive or negative terminal of a single output module may be grounded. Dual output modules have a positive/common/negative output terminal configuration.

Ambient Operating Temperature: −20 to +71°C. (Model 5E150 and 5EB150, 0 to +71°C.) No derating required.

Temperature Coefficient: 5-volt models, .03%/°C; dual output models, .015%/°C.

Impedance: 0.07 ohm at 1 kHz, 0.2 ohm at 10 kHz (approx.).

Optional 230 Volt Input: To order, add suffix "-230" to model number and $10.00 to price.

Case Sizes and Weight:
EB-10: 3.5″ x 2.5″ x 1.375″ (1 lb)
EB-13: 3.5″ x 2.5″ x 1.625″ (1 lb 5 oz)
EB-20: 3.5″ x 2.5″ x 2.375″ (2 lb 1 oz)
EL-10: 3.5″ x 2.5″ x 1″ (15 oz)
EL-13: 3.5″ x 2.5″ x 1.25″ (1 lb 3 oz)
EL-20: 3.5″ x 2.5″ x 2″ (2 lb)
ES-10: 2.3″ x 1.8″ x 1″ (7 oz)

Other models available from 1 to 75 volts. Send for complete information.

Acopian Corp., Easton, Pa. 18042 Tel: (215) 258-5441

For more information, Circle No 49

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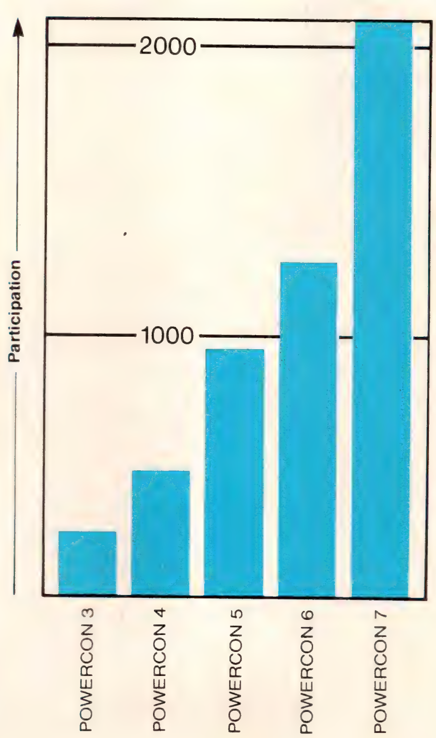

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Name ____________ **Title** ____________

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Switching power supplies

Tailoring a switching power supply *to meet your special needs is one option today's product choices provide. (Photo courtesy Boschert Inc)*

The latest switchers allow you to take advantage of their low cost and small size in a wider variety of applications than ever.

Edward R Teja, Associate Editor

Whether or not switchers will eventually replace linear power supplies for all applications remains to be seen; but even now, they have changed the way you must think about powering your designs.

The latest switchers don't necessarily provide more features or a higher level of sophistication than linear supplies. Their significance comes from more basic values: They provide a system with all the power it needs while occupying less space and producing less heat than equivalent linear units—all at lower prices than linears for units supplying more than 50W. (Although one switcher advance—higher-than-100-kHz switching frequencies—will ultimately enhance these benefits, it hasn't appeared in products as rapidly as anticipated and might not prove as great a boon as some designers expect.)

To take advantage of switchers' benefits, however, you must avoid designing your system first and then allocating the leftover space to the power supply; if you follow this approach, you lose the flexibility to make advantageous tradeoffs among switchers' wide selection of packages, features, power levels and voltages. Instead, consider the supply at the beginning of the design procedure.

An efficient operation

The advantage of switching power supplies lies in their ability to operate inside your system with only convection cooling. Although all switchers can't work this way—some high-power units do employ fans—open-frame supplies, at least, carry on the tradition.

Switchers don't care for high-temperature operation any more than linear units do, but the more efficient switchers generate less heat for any given task than linears do. It isn't unusual to see data sheets claiming 70 to 85% efficiency as a matter of course, with the more exotic switchers operating at more than 90% efficiency.

Note, however, that because efficiency is a widely touted specification, you must understand the many different ways manufacturers measure it. Although the definition of efficiency makes its calculation seem straightforward—divide the output power by the input power—actually measuring the input power can be a problem, according to RO Associates marketing vice president Richard Okada.

Why? Most power supplies employ a capacitive input filter. Thus, their input currents aren't sinusoidal, and conventional power-factor formulas don't apply. And if you try to measure the power with an integrating wattmeter, you probably won't get a valid reading, because some meters assume sinusoidal waveforms and others don't integrate quickly enough to measure the actual current.

Okada suggests applying dc to the supply's input for power measurements. (If your supply has an input transformer, you'll have to measure the transformer's losses separately.) The dc input lets you measure input and output power accurately and accounts for all losses except those in the input rectifier, which shouldn't affect accuracy by more than 1%.

If you doubt such a measurement's results, you can cross check them by measuring the actual heat loss in the supply—performing a calorimetric measurement.

High efficiency permits tiny size

One exciting aspect of switchers' cool operation comes in the form of small dc/dc converters that mount on pc boards. Tecnetics Inc, for example, sells a 1W hybrid unit that measures 1.05×0.94×0.32 in. and fits in a DIP socket. It provides power conversion and isolation on cards where heat sinking isn't available. The supply accepts 5 to 28V and furnishes 5 to 300V; if you need dual outputs, they can each supply 5 to 24V.

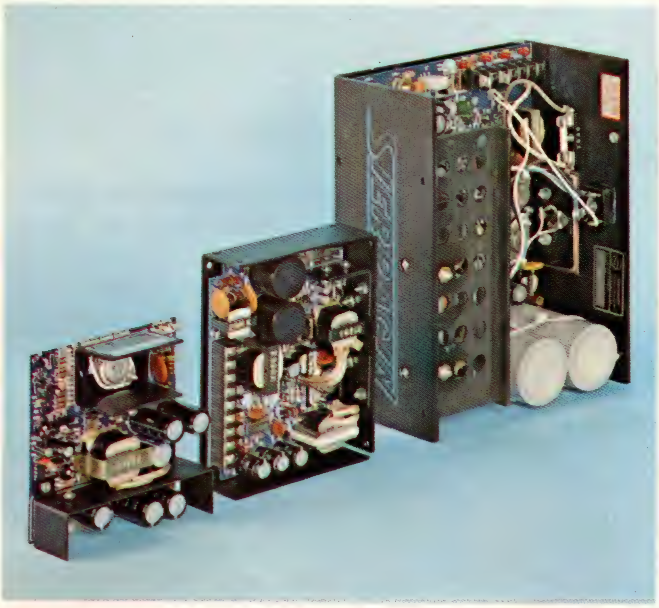
Efficient switcher technology puts supplies on pc boards

Because these encapsulated units (either hermetically sealed or potted) cost \$75 apiece, though, they primarily suit less cost-conscious military applications.

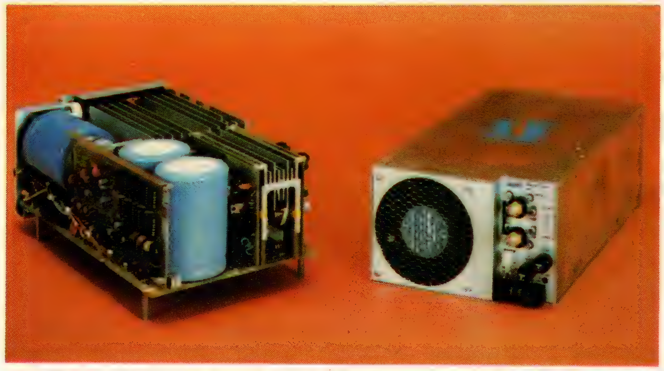
Another small unit—a cube measuring $\frac{1}{2}$ in. on a side—provides 40 mW of unregulated dc from a 90 to 255V ac supply. Suitable for driving LCD panel meters and other low-power devices, the Microsource costs only \$3.55 (100). Higher power costs more, of course: A 100-mW $\frac{1}{2}\times\frac{3}{4}\times\frac{3}{4}$-in. version runs \$3.57, and with regulation on all outputs, it's priced at \$5.07 (100). And a recently introduced $\frac{3}{4}\times\frac{3}{4}\times\frac{3}{4}$-in. member of this miniature family produces a whopping $\frac{3}{4}$W for approximately \$22.

Stevens-Arnold has applied switcher technology in developing its wide-input-range, single-output dc/dc Switchpak modules. These 88%-efficient supplies provide 15 to 50W on pc cards. Intronics also offers modular power supplies. The SME Series, for example, converts ac to dc, delivering 2.5W and more. Various packages provide one 5V output at 500 mA (\$41) and triple outputs of 5V and either ±12V or ±15V (\$114). And the firm's recently introduced DCS Series meets dc/dc-conversion requirements for 30 to 100W.

Note that the modular approach allows you to standardize at least part of your power-supply design. You can utilize dc/dc converters from firms such as Endicott Research Group to transform the voltage from standard power supplies to nonstandard values as needed. Thus, you can buy one single-voltage supply and convert its output to any level between 5 and 1000V at 3, 6, 12 or 25W for about \$1 per watt.



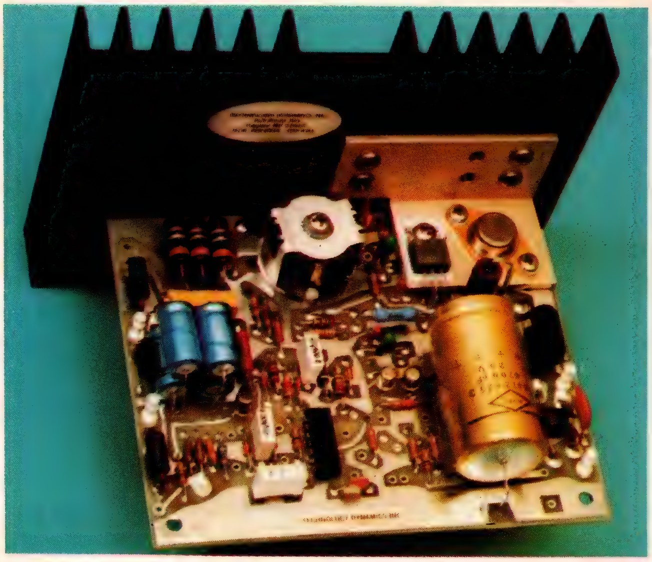
Providing dc power from 40 to 500W, *Sierracin/Power Systems' switching-supply family members furnish a broad choice.*



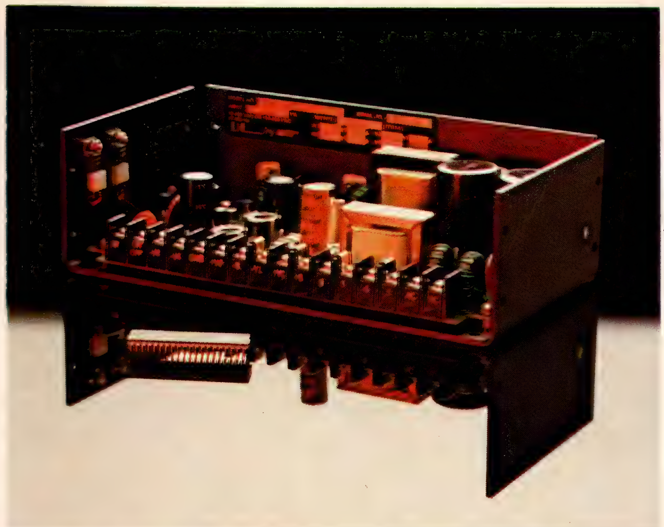
The first switcher to break the 1000W barrier *in a 5×8-in. box came from Boschert Inc. This Model HL1500 provides 5V at 300A.*

Modular power supplies *from Intronics convert ac to dc right on a circuit card.*

For 1000W delivered as 5V at 200A, *try Pioneer Magnetics' Model PM 2500A.*



Switching regulators, *such as Technology Dynamics' Model SR50P, can deliver 50W in a small package.*



Operating at 40 kHz, *LH Research's Teeny Tiny-Mite Series supplies provide power to 100W. The µP in the foreground provides a size comparison.*

The selection doesn't stop here, either. Power/Mate sells encapsulated supplies, the Mini/Mate Series, that convert ac to dc on circuit boards (units priced at $35 to $102), provide higher power from a chassis-mounted device ($69 to $130) or convert dc to dc in 5 to 6W and 10 to 12W packages ($94 to $99). And offering a 25W board-mountable switcher that competes in price with 5W encapsulated linear supplies, Power General sells its Series 325 units for $89. These off-line switchers measure 2.75×4×1.375 in. and furnish 80% efficiency.

With yet another alternative, Powercube's Cirkitblock Modules furnish the means for creating a custom supply for your application at any power rating between 50 and 100W. You select the appropriately spec'd switching preregulator, high-frequency generator and transformer-isolated output modules. For high-power applications, the Cirkitblocks mount inside heat sinks.

Keep the supply in the open

Although such modules and modular supplies are important because they let you take advantage of switcher technology in a custom manner, they don't represent the mainstream of switcher technology. The switchers that have really made inroads into the linear-power-supply market are open-frame supplies in the 50 to 500W range.

Open-frame switchers have broken the price barriers between switchers and linear supplies apparent over the last couple of years and typically provide the lowest cost solutions to medium-power, multiple-output needs. The classic application for switchers—EDP equipment—exemplifies these requirements; it also requires the small dimensions associated with switchers.

Open-frame switchers don't usually come as single catalog items; each model actually represents a variety of versions. In this sense, most open-frame supplies are customized for specific applications. Note that each manufacturer offers products in a range of power levels and that low-power units operate according to flyback principles unlike those of higher power supplies. And because open-frame supplies generally demand different manufacturing talents than do enclosed units, the products a manufacturer chooses to offer tell you something about the areas of its expertise. Only the largest firms can afford continuing development of every switcher power rating and configuration.

One manufacturer, Sierracin/Power Systems, produces a fairly comprehensive line of switchers. This family covers power levels from 40 to 500W in a variety of output-voltage levels. Another firm, Boschert, markets open-frame units well down in the low-power range. Its standard 25W Model OL-25, for instance, suits small µP systems, desktop calculators and mini CRT displays. The $80 (100) unit measures only 2.5×4×6 in.

Powertec keeps expanding its Valuswitcher 19 open-frame line, which now includes units providing four voltage outputs at six power levels from 50 to 400W. You can order all auxiliary outputs with either partial or full regulation. In the latter case, all outputs stay within 0.2% over 20 to 100% of rated load.

For low-power applications, LH Research has introduced the 40-kHz Teeny Tiny-Mite (TTM) Series; it includes 16 basic models that output combinations of dc levels up to 100W total. Prices range from $205 (5V at 12A and 12V at 1.5A) to $275 (5V at 12A, 15V at 3A, −15V at 1.5A, −5V at 0.5A and 24V at 2A). These supplies exhibit an extended hold-up time (the time a switcher's output takes to drop after the ac input drops out) of 20 msec, compared with the standard 16-msec spec most switchers provide. Error-proof voltage sequencing and power-fail detection come standard.

If you need only 75W, consider Condor Inc's $150 Model MDS-75. This 75%-efficient (at 75W) supply restricts inrush current to 25A max and holds output ripple to 2% p-p on all outputs.

Another alternative, the Econoswitch Series from Power/Mate, gives you a choice of two broad lines—one featuring single-output units, the other offering multiple voltages. A monolithic chip containing the

Open-frame supplies furnish an alternative to custom units

supplies' regulation, modulation and protection circuitry reduces parts count by as much as 20%. Prices range from $79 for 18W single-voltage units to $399 for a multiple-output 300W supply.

Lambda Electronics—one of the pioneers in switchers—offers supplies that suit the same applications as open-frame units, yet are completely enclosed. Members of the LU Series, for instance, provide 5V at 3A in 3.82×1.38×3.54-in. packages for $46. Other models furnish 12, 15 and 24V at the same price.

Finally, Elpac Power Systems makes one of the few switching supplies advertised as a convertible. Although most open-frame units require relayout and perhaps redesign to operate enclosed, you can get Elpac's ES130 switchers in either configuration. The 4-output supplies cost $182 (250) as open-frame units and $189 (250) enclosed. Designated the Ugly switchers, they produce 5V at 20A; auxiliaries are available for 12V at 1.5A, 15V at 1.2A and 5V at 0.5A.

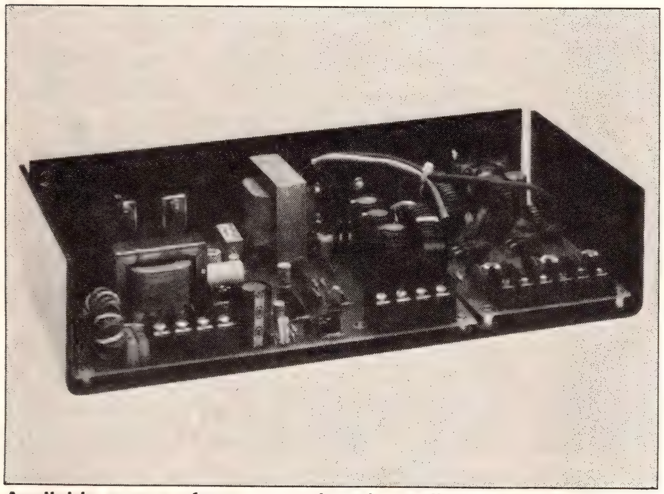
The choice is yours

Open-frame supplies provide you with a multitude of features; output power, dc voltages, regulation, logic signals such as power-fail detect and other options all enter into a design decision. But except for supplies such as those in Power/Mate's Econoswitch Series, open-frame switchers aren't merely enclosed supplies with their lids removed; they tend to be designed for simplicity, both in their operation and manufacture.

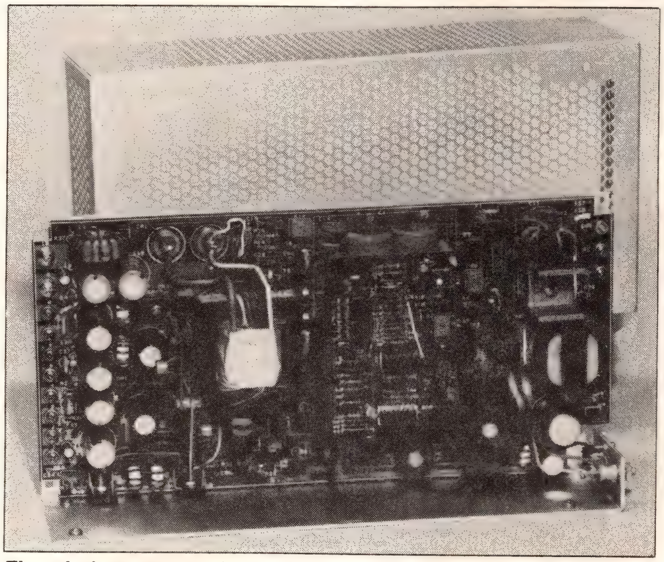
Most open-frame units, for example, use only one pc card and are laid out much like their block diagrams indicate. In the case of the National Power Technology (NPT) switchers, for instance, you could confuse the circuit's board-layout plan with its block diagram; you can start at one end of the circuit board and trace the power flow from the ac input through the line filters and soft-start circuits to the control circuits and out the regulators.

This type of layout helps hold prices down because the manufacturer doesn't have to consume time and money dealing with the interaction of inputs and outputs—they never come close to each other. NPT's 200W switchers cost $239 (100).

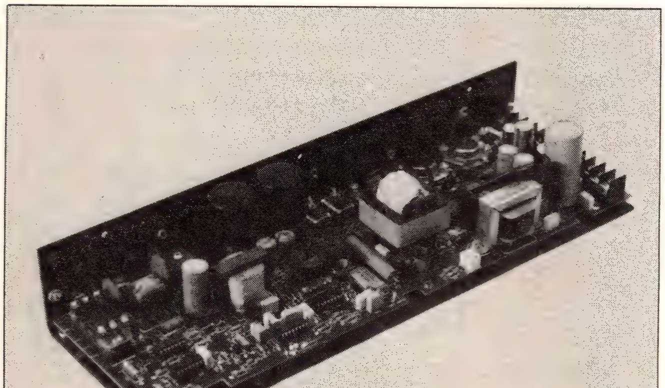
Another manufacturer, Kepco, exemplifies the drive



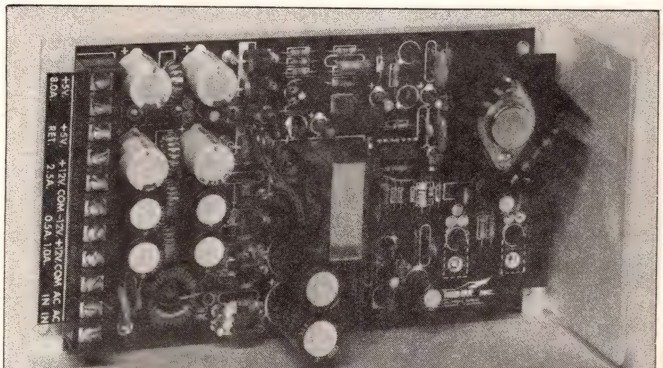
Available as open-frame or enclosed supplies, *units in the ES 130 line come from Elpac Power Systems. The open-frame versions cost $182 (250); enclosed units, $189 (250).*



Five independent dc outputs *produce a total of 300W in Power/Mate's ESM 300 Series.*



One pc board and a few components *furnish 200W in National Power Technology's open-frame switcher.*



Restricting inrush current to 25A, *Condor Inc's Model MDS-75 costs only $150.*

to bring costs down by using a different approach. In a joint effort with TDK, it has built a plant in Japan dedicated to building its EFX power supplies as inexpensively as possible. The plant began operation last year with 65% of the assembly procedures automated; by the end of this year, Kepco expects to have automated 85% of the processes involved in transforming bare circuit boards into finished power supplies. The firm feels that this approach produces supplies in large quantities while maintaining their reliability and reproducability.

A typical EFX model provides multiple outputs, is rated at 50W and suits EDP applications; it costs $84 in OEM quantities. Other EFX-family members extend the range to 300W.

Custom-made versatility

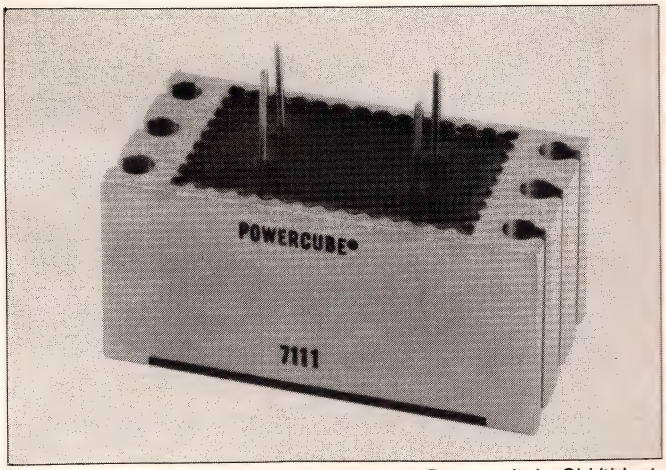
The myriad versions of each manufacturer's open-frame units exist because a certain degree of uniformity, combined with the right amount of versatility, produces power supplies exactly tailored to an application—without the premium charged for truly custom supplies. If you envision large production runs, though, you might well decide that a true custom supply is an item your design can't live without. Space limitations or special power requirements sometimes preclude using even one of the tailored open-frame units, and custom-switcher prices can be reasonable in high-volume applications (but see **box,** "Buy or build?").

If, for example, you're designing a system for the Space Shuttle, cost becomes less of a factor than getting exactly the power supply you need—in terms of reliability and durability as well as the proper voltages and currents. And you might choose to do exactly what the Shuttle's equipment designers did: approach a modular-switcher house such as Arnold Magnetics.

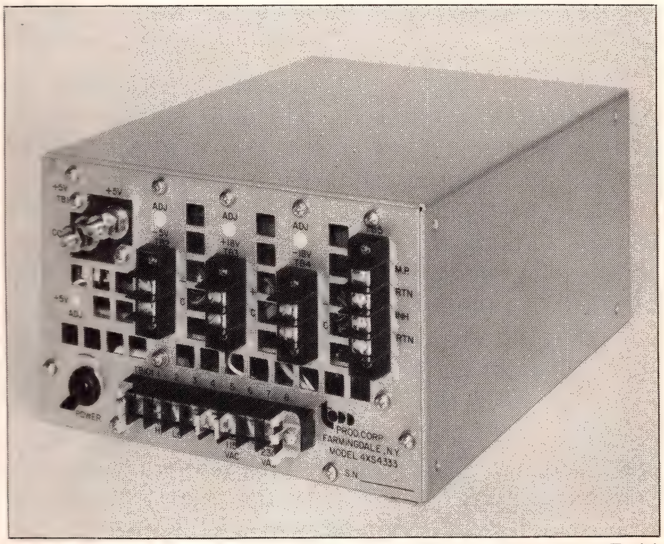
Prices for custom switchers run a bit higher than those for conventional industrial units (a typical 4-output, 200W Arnold supply costs $1100), but you get a unit that exceeds the rugged MIL-STD-810C and have it delivered within 8 wks. Not bad for a custom order.

Check out the subtle design factors

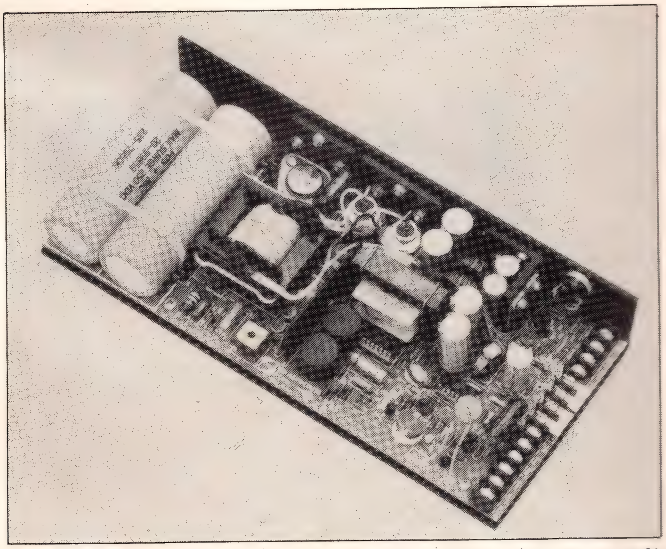
How do you find the right unit for your application among the many different switchers discussed here? For one thing, examine such subtle factors as the way switchers would mount in your design. Additionally,



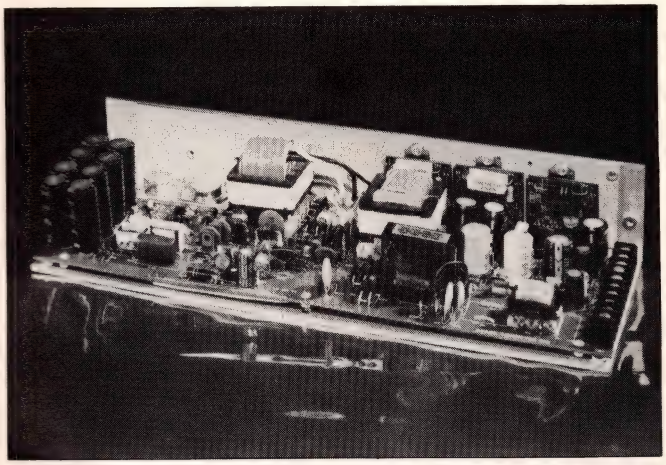
Build a custom switching supply *using Powercube's Cirkitblock modules.*



High-power switchers *usually provide a single voltage, but Todd Products Corp's SM3 brings 750W to the party in four outputs.*



Four common voltages *(5V at 15A, ±12V at 1.5A and −5V at 0.5A) provide 111W from RO Associates' $225 Model 912.*



Get four voltage outputs *at six power levels between 50 and 400W from Powertec's Valuswitcher 19 Series.*

Ordering only the regulation required can save money

Power/Mate marketing VP Joe Geronimo suggests that you consider other parameters:

- **Input-voltage range**—A considerable price difference exists between a 90 to 130V ac-input supply and a 105 to 125V unit.
- **Separate ground returns**—Requiring a separate ground return for each supply output can reduce crosstalk.
- **Ripple and noise**—Specs can vary substantially, but a good switcher exhibits 50 to 75 mV p-p.

One last factor you must consider is whether you need regulation on all outputs. Each manufacturer provides a different regulation solution.

A great deal of effort has been required to convince system designers that every application doesn't need the 0.005% regulation linears offer so effortlessly. In this respect, Boschert Inc engineering VP Bob Boschert was a prime mover in pointing out that open-frame switchers with quasiregulation on auxiliary outputs suit many applications. In doing so, he opened the flood gates for the widespread use of this type of unit.

The argument against demanding regulation on every output is simple: If you manufacture a high-volume product, you can save a great deal of money by not paying for regulation where it isn't needed.

All switcher outputs do provide some regulation, though; a feedback loop stabilizes the primary output voltage, furnishing both line and load regulation. All auxiliary outputs benefit from such line regulation, too, but they don't have load regulation unless it's specifically added. These outputs' regulation can vary from 20 to 100%, according to ACDC Electronics's head of new-product development, Walter Hirschberg. He adds that you must also deal with some interaction between the main and auxiliary outputs.

Buy or build?

Jeff Shepard, LH Research Inc

(Ed note—The biggest competition faced by power-supply manufacturers comes from firms that design their own supplies. But many of these OEMs don't really understand the problems involved in such an undertaking. Here's one expert's look at what the task entails.)

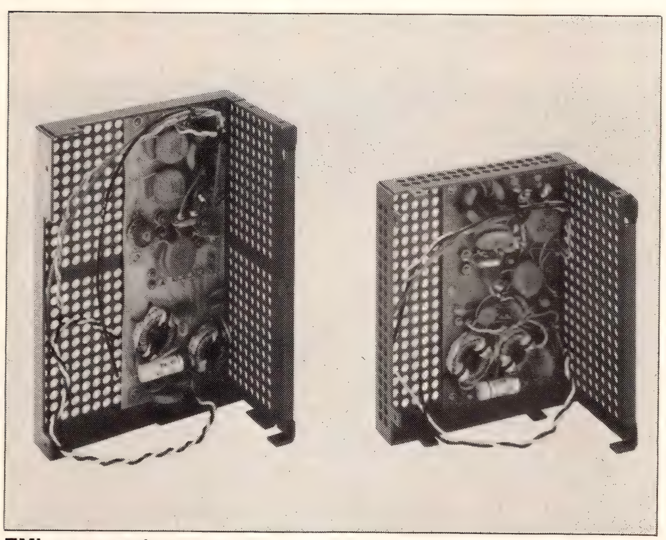
If your company produces power supplies strictly for internal consumption, you'll encounter inflexibilities in the use of materials, parts or supplies compared with the situation of buying the complete unit outside. Purchasing another manufacturer's power supplies, however, permits you to buy from whatever source offers the best combination of price, quality and service. And you're then free to substitute items, shift vendors or split orders among competitors.

Additionally, companies that produce their own supplies can rarely afford the research-and-development effort available to firms that make power supplies their primary business. Manufacturing power supplies for internal use involves new equipment, new skills, new technology and new personnel.

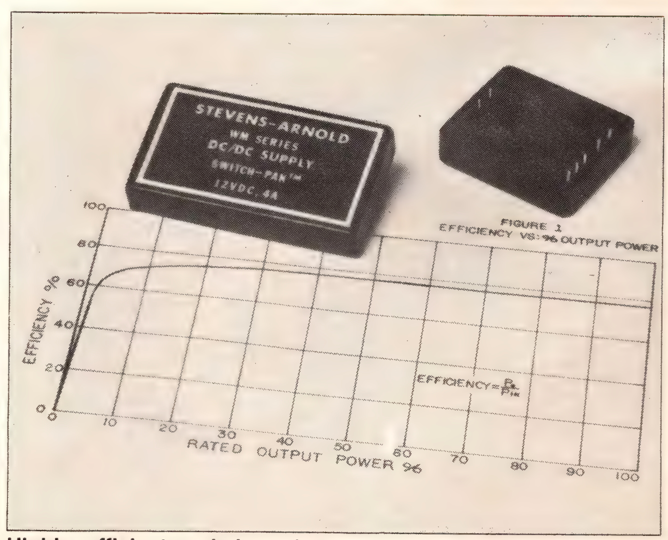
And if you intend to sell large numbers of units, you must ensure that your supply-production operation can meet the demand. Your designs must be flexible enough to meet all your system needs, too.

Unfortunately for designers, switchers involve high-power, nonlinear analog feedback circuits requiring production techniques that differ from most of those used in host digital systems. Thus, think twice before designing your own switchers.

(The author is manager of marketing operations at the Tustin, CA-based firm.)



EMI-suppression covers *for Lambda switchers include filters to reduce conducted emissions.*



Highly efficient switch-mode operation *suits Stevens-Arnold's dc/dc supplies for use on pc boards.*

VOLTAGE & CURRENT RATINGS

DUAL OUTPUT

MODEL	REGULATION (LINE OR LOAD)	RIPPLE (RMS)	VOLT VDC	[1]MAX CURRENT AMPS AT 40°C	50°C	60°C	71°C	PKG SIZE	DIMENSIONS[2] (INCHES)	PRICE
5 VOLTS ±5% ADJ., 9V-12V ADJ.										
LND-X-MPU[3]	0.1%	1.5	5±5% 9—12	7.0 (5.95) 1.2 (1.02)	6.0 (5.11) 1.1 (0.94)	4.7 (4.0) 1.0 (0.85)	3.2 (2.72) 0.8 (0.68)	X	7 x 4-7/8 x 2-7/8	$172
LND-P-MPU[3]	0.1%	1.5	5±5% 9—12	14.0 (13.3) 2.5 (2.38)	12.2 (11.59) 2.2 (2.09)	10.0 (9.5) 1.8 (1.71)	7.5 (7.13) 1.35 (1.28)	P	11 x 4-7/8 x 4-13/32	245

DUAL TRACKING

MODEL	REGULATION (LINE OR LOAD)	RIPPLE (RMS)	VOLT VDC	40°C	50°C	60°C	71°C	PKG SIZE	DIMENSIONS (INCHES)	PRICE
±15 VOLTS TO ±12 VOLTS ADJ.										
LND-Z-152	0.15%	1.5	±15 to ±12	0.6 (0.54) 0.6 (0.54)	0.55 (0.5) 0.55 (0.5)	0.45 (0.41) 0.45 (0.41)	0.3 (0.27) 0.3 (0.27)	Z	4-7/8 x 4 x 1-3/4	85
LND-Y-152	0.1%	1.5	±15 to ±12	1.4 (1.20) 1.2 (1.02)	1.2 (1.02) 1.1 (0.94)	0.9 (0.77) 0.8 (0.68)	0.6 (0.51) 0.5 (0.43)	Y	5-5/8 x 4-7/8 x 2-5/8	120
LND-X-152	0.1%	1.5	±15 to ±12	2.5 (2.13) 2.3 (1.96)	2.1 (1.79) 1.9 (1.62)	1.6 (1.37) 1.4 (1.2)	1.1 (0.94) 0.9 (0.77)	X	7 x 4-7/8 x 2-7/8	150
LND-W-152	0.1%	1.5	±15 to ±12	3.3 (3.0) 3.1 (2.8)	3.1 (2.8) 2.8 (2.52)	2.6 (2.34) 2.3 (2.07)	2.0 (1.8) 1.6 (1.44)	W	9 x 5 x 2-7/8	170
LND-P-152	0.1%	1.5	±15 to ±12	5.3 (5.04) 4.6 (4.37)	4.7 (4.47) 4.0 (3.80)	3.9 (3.71) 3.3 (3.14)	2.9 (2.76) 2.5 (2.38)	P	11 x 4-7/8 x 4-13/32	240

SINGLE OUTPUT

MODEL	REGULATION (LINE OR LOAD)	RIPPLE (RMS)	[1] MAX CURRENT AMPS AT 40° C	50° C	60° C	71° C	PKG SIZE	DIMENSIONS[2] (INCHES)	PRICE
5 VOLTS ±5% ADJ.									
LNS-Z-5-OV	0.15%	1.5	3.0 (2.7)	2.7 (2.4)	2.3 (2.1)	1.7 (1.5)	Z	4-7/8 x 4 x 1-3/4	$ 80
LNS-Y-5-OV	0.1%	1.5	6.0 (5.4)	5.1 (4.6)	4.2 (3.8)	3.1 (2.8)	Y	5-5/8 x 4-7/8 x 2-5/8	115
LNS-X-5-OV	0.1%	1.5	10.0 (8.5)	8.9 (7.6)	7.3 (6.2)	5.3 (4.5)	X	7 x 4-7/8 x 2-7/8	140
LNS-W-5-OV	0.1%	1.5	14.0 (11.9)	12.2 (10.4)	10.0 (8.5)	7.5 (6.4)	W	9 x 5 x 2-7/8	175
LNS-P-5-OV	0.1%	1.5	22.0 (20.9)	19.5 (18.53)	16.5 (15.68)	13.0 (12.35)	P	11 x 4-7/8 x 4-13/32	220
6 VOLTS ±5% ADJ.									
LNS-Z-6	0.15%	1.5	2.5 (2.25)	2.2 (2.0)	1.9 (1.7)	1.4 (1.3)	Z	4-7/8 x 4 x 1-3/4	75
LNS-Y-6	0.1%	1.5	5.6 (5.0)	4.9 (4.4)	4.0 (3.6)	2.9 (2.61)	Y	5-5/8 x 4-7/8 x 2-5/8	110
LNS-X-6	0.1%	1.5	9.5 (8.1)	8.4 (7.15)	7.1 (6.0)	5.0 (4.25)	X	7 x 4-7/8 x 2-7/8	130
LNS-W-6	0.1%	1.5	13.0 (11.0)	11.2 (9.5)	9.3 (7.9)	6.8 (5.9)	W	9 x 5 x 2-7/8	165
LNS-P-6	0.1%	1.5	20.5 (19.48)	18.1 (17.2)	15.3 (14.54)	12.0 (11.4)	P	11 x 4-7/8 x 4-13/32	200
12 VOLTS ±5% ADJ.									
LNS-Z-12	0.15%	1.5	1.7 (1.55)	1.6 (1.45)	1.5 (1.4)	1.3 (1.2)	Z	4-7/8 x 4 x 1-3/4	75
LNS-Y-12	0.1%	1.5	4.0 (3.6)	3.5 (3.15)	2.9 (2.6)	2.2 (2.0)	Y	5-5/8 x 4-7/8 x 2-5/8	110
LNS-X-12	0.1%	1.5	6.5 (5.5)	5.5 (4.7)	4.5 (3.8)	3.3 (2.8)	X	7 x 4-7/8 x 2-7/8	130
LNS-W-12	0.1%	1.5	8.5 (7.2)	7.2 (6.1)	5.9 (5.0)	4.2 (3.6)	W	9 x 5 x 2-7/8	165
LNS-P-12	0.1%	1.5	14.0 (13.3)	12.4 (11.8)	10.0 (9.5)	7.3 (6.94)	P	11 x 4-7/8 x 4-13/32	200
15 VOLTS ±5% ADJ.									
LNS-Z-15	0.15%	1.5	1.4 (1.3)	1.3 (1.62)	1.2 (1.1)	1.0 (0.9)	Z	4-7/8 x 4 x 1-3/4	75
LNS-Y-15	0.1%	1.5	3.4 (3.1)	3.1 (2.8)	2.6 (2.35)	2.0 (1.8)	Y	5-5/8 x 4-7/8 x 2-5/8	110
LNS-X-15	0.1%	1.5	5.5 (4.7)	4.8 (4.1)	3.9 (3.35)	2.8 (2.4)	X	7 x 4-7/8 x 2-7/8	130
LNS-W-15	0.1%	1.5	7.7 (6.55)	6.7 (5.7)	5.5 (4.7)	3.8 (3.15)	W	9 x 5 x 2-7/8	165
LNS-P-15	0.1%	1.5	12.0 (11.4)	10.6 (10.1)	8.5 (8.1)	6.3 (6.0)	P	11 x 4-7/8 x 4-13/32	200
20 VOLTS ±5% ADJ.									
LNS-Z-20	0.15%	1.5	1.0 (0.69)	0.85 (0.77)	0.65 (0.59)	0.45 (0.41)	Z	4-7/8 x 4 x 1-3/4	75
LNS-Y-20	0.1%	1.5	2.7 (2.45)	2.5 (2.25)	2.0 (1.08)	1.3 (1.2)	Y	5-5/8 x 4-7/8 x 2-5/8	110
LNS-X-20	0.1%	1.5	4.4 (3.75)	3.6 (3.1)	2.6 (2.2)	1.6 (1.4)	X	7 x 4-7/8 x 2-7/8	130
LNS-W-20	0.1%	1.5	6.1 (5.2)	5.2 (4.4)	4.2 (3.6)	3.0 (2.6)	W	9 x 5 x 2-7/8	165
LNS-P-20	0.1%	1.5	10.0 (9.5)	8.9 (8.46)	7.5 (7.13)	5.5 (5.23)	P	11 x 4-7/8 x 4-13/32	200
24 VOLTS ±5% ADJ.									
LNS-Z-24	0.15%	1.5	0.9 (0.81)	0.75 (0.68)	0.6 (0.55)	0.4 (0.36)	Z	4-7/8 x 4 x 1-3/4	75
LNS-Y-24	0.1%	1.5	2.3 (2.1)	2.1 (1.9)	1.7 (1.5)	1.1 (1.0)	Y	5-5/8 x 4-7/8 x 2-5/8	110
LNS-X-24	0.1%	1.5	3.8 (3.25)	3.2 (2.75)	2.4 (2.0)	1.4 (1.2)	X	7 x 4-7/8 x 2-7/8	130
LNS-W-24	0.1%	1.5	5.4 (4.6)	4.6 (3.9)	3.7 (3.1)	2.5 (2.1)	W	9 x 5 x 2-7/8	165
LNS-P-24	0.1%	1.5	9.0 (8.55)	8.0 (7.6)	6.7 (6.37)	5.0 (4.75)	P	11 x 4-7/8 x 4-13/32	200
28 VOLTS ±5% ADJ.									
LNS-Z-28	0.15%	1.5	0.8 (0.75)	0.65 (0.6)	0.5 (0.45)	0.35 (0.32)	Z	4-7/8 x 4 x 1-3/4	75
LNS-Y-28	0.1%	1.5	2.0 (1.8)	1.8 (1.65)	1.5 (1.35)	1.0 (0.9)	Y	5-5/8 x 4-7/8 x 2-5/8	110
LNS-X-28	0.1%	1.5	3.4 (2.9)	2.9 (2.5)	2.2 (1.5)	1.2 (1.0)	X	7 x 4-7/8 x 2-7/8	130
LNS-W-28	0.1%	1.5	4.7 (4.0)	4.0 (3.4)	3.2 (2.75)	2.2 (1.9)	W	9 x 5 x 2-7/8	165
LNS-P-28	0.1%	1.5	8.0 (7.6)	7.1 (6.75)	6.0 (5.7)	4.5 (4.28)	P	11 x 4-7/8 x 4-13/32	200
48 VOLTS ±5% ADJ.									
LNS-P-48	0.1%	1.5	4.5 (4.28)	4.0 (3.8)	3.4 (3.2)	2.5 (2.38)	P	11 x 4-7/8 x 4-13/32	250

NOTE: 1. Rating in Parenthesis or LNSeries when cover is used.
2. Dimensions include cover.
3. Includes OV protection on both outputs (5V OV trip point is 6.6 ±.2V fixed; 9—12V OV trip points is 13.7 ±.4V fixed).

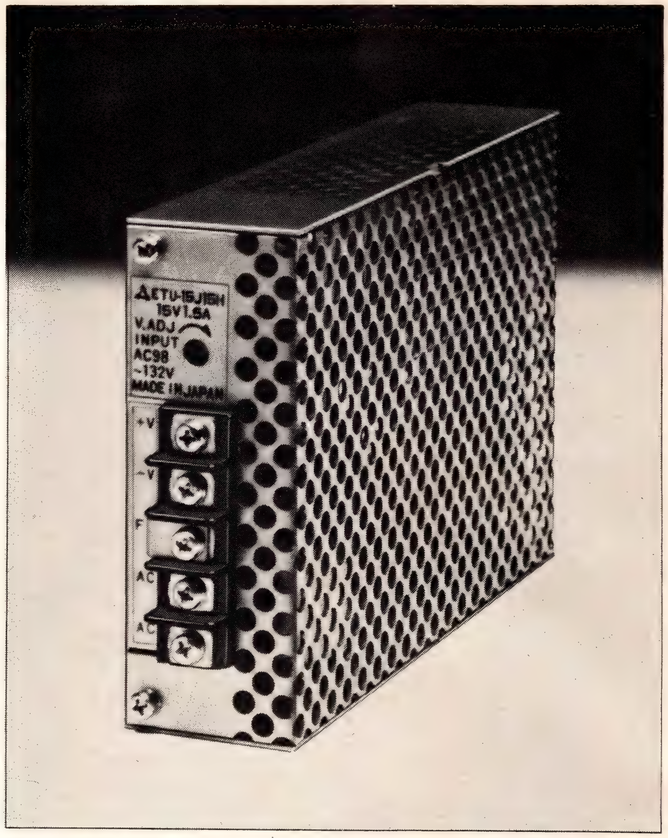
A typical open-frame-switcher data sheet—*in this case, for Lambda's LN Series—indicates the wide range of specs you can choose from.*

Boxed switchers provide up to 1500W

As an example of switcher regulation, consider the block diagram of Adtech Power's patented 1-transistor, pulse-width-modulated Univerter design (**Fig 1**). This circuit provides one semiregulated output (line regulation only) along with a tightly regulated primary and one fully regulated secondary. Notice that a post regulator furnishes the secondary's regulation.

Some manufacturers choose to offer regulation on all outputs and sell supplies without this feature only on a custom basis. National Power Technology designers, for example, feel that a supply with unregulated outputs is vulnerable to damage if its host system's loads aren't what the system designer expects them to be. Thus, putting regulators on all outputs prevents catastrophic failures.

Sierracin/Power Systems contends that although you might find applications (such as daisy-wheel printers) that do allow use of unregulated auxiliary outputs, the approach isn't generally a good idea. According to the firm's VP for engineering, Ken Lauchner, the typical ±5% of line and load regulation combines with another ±3% of cross regulation, ±2% of thermal drift and 200 mV of distribution losses to introduce a worst-case output variation exceeding 10%. You can make sure a



Measuring 5.35×3.82×1.18 in., *Panasonic's J Series 20W switchers come in 5V/4A, 12V/1.8A, 15V/1.5A and 24V/1A versions and operate to full rating at 50°C with normal convection cooling. The manufacturer warrants them for 3 yrs.*

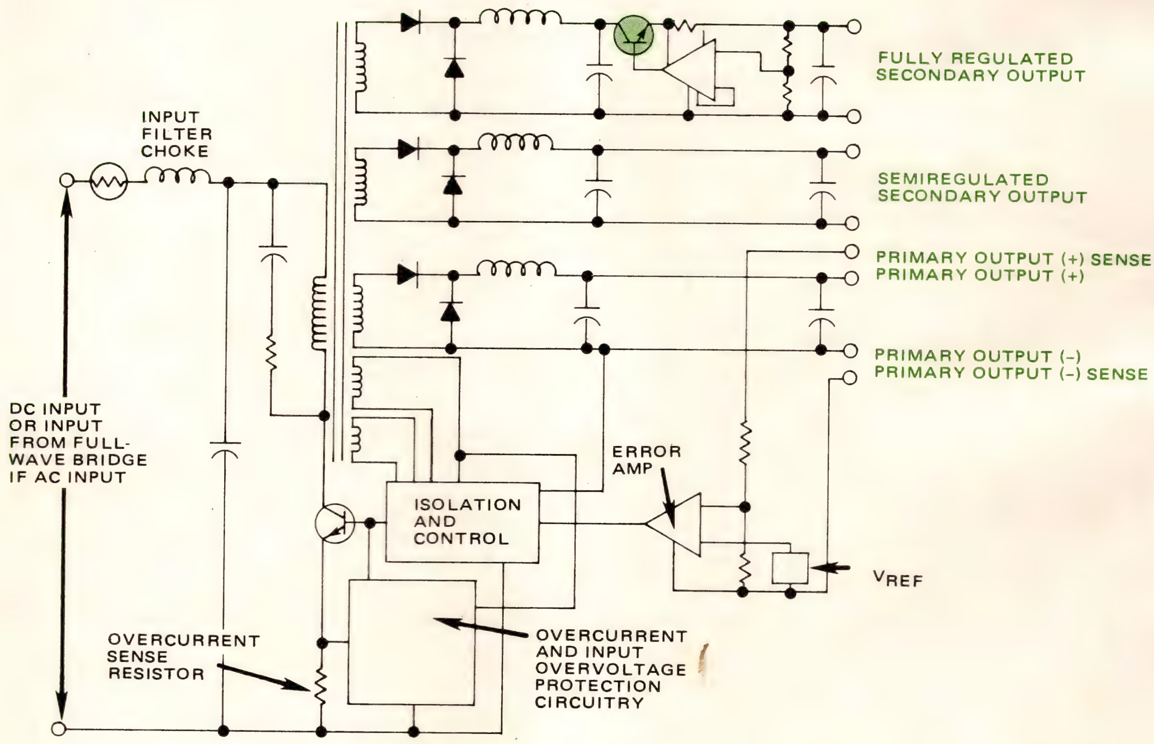
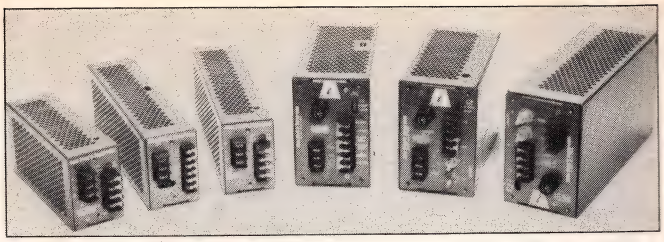


Fig 1—A 1-transistor circuit *provides a fully regulated primary output, one regulated secondary and a semiregulated output in Adtech Power Inc's patented Univerter.*



Thirty-nine models *in the AMS Series from Acme Electric Corp furnish output voltages from 2 to 28V dc and power capability of 100 to 625W.*

$46 buys a variety of low-power options *in Lambda's LU Series.*

given output variation won't affect your system adversely only by testing a supply under all of the system's static and dynamic load conditions. If the variation might cause damage, you can't use the supply without adding at least some regulation.

Put more power in the box

With or without regulation, switchers have now moved into applications previously in the domain of linears, as well as opening up new applications themselves. And product development continues at all power levels.

Examining switchers' inroads into linear territory, Sierracin's Lauchner believes that the switcher-vs-linear crossover-pricing curve shown in **Fig 2** tells the story. Yet others feel that the curve might prove misleading. Bob Boschert, for instance, insists that no such curve exists at all. The market for switchers, he argues, encompasses a set of discrete-power-level requirements for which available switchers are more cost effective than equivalent linear supplies.

Even if power-supply pricing does follow the curve, the chart erroneously implies that above 600W switchers cost less than linear supplies. The graph, however, begins at 600W because the first switchers to compete in price with linears were 600W units.

Switching supplies have made selective inroads in the high-power region, though. Most of these units come in 5×8×10 (or 11)-in. cases and furnish only one output

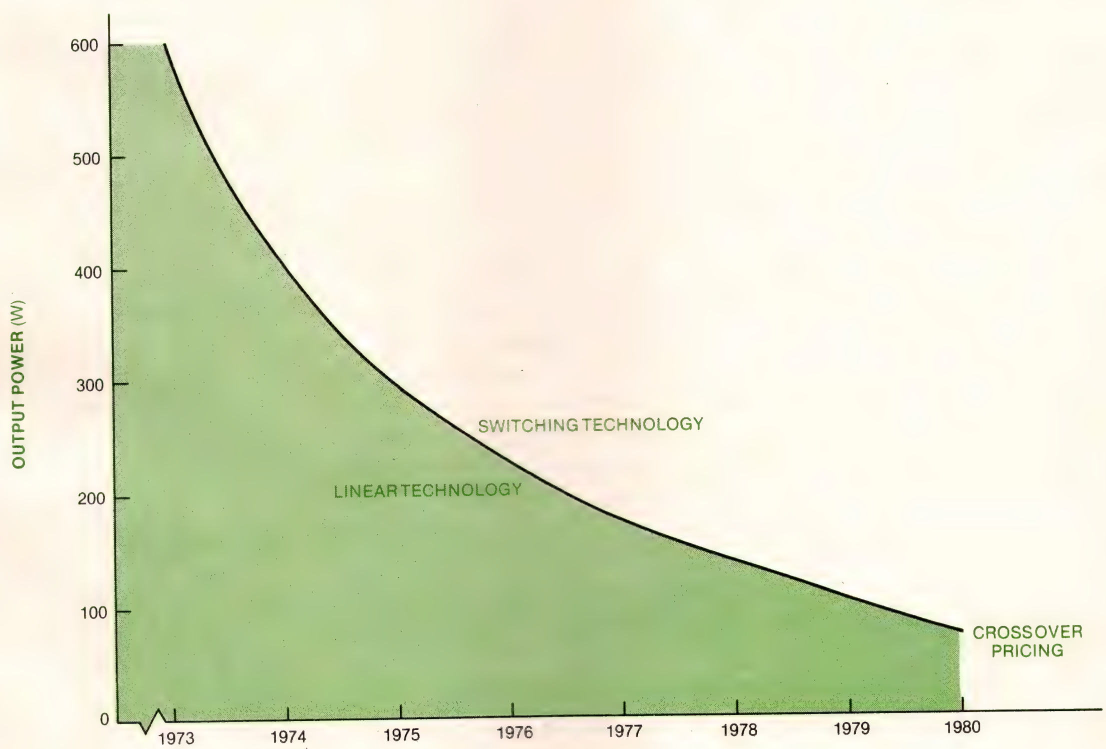


Fig 2—The pricing-crossover point *between linear supplies and switchers has rapidly moved down from its location at 600W in 1973. (Courtesy Sierracin/Power Systems)*

High-frequency switching permits smaller supplies

voltage. They use their cases as heat sinks and employ fans to help stay cool.

Pioneer Magnetics' Model PM 2500A, for example, provides 1000W, delivering 5V at 200A. You don't get the flexibility provided by low-power open-frame supplies, but you do receive a reliable unit that the manufacturer terms a workhorse. (The Editor's Choice on pg 83 illustrates the next evolutionary step in this line.)

Boschert also packs a lot of power in a 5×8-in. box. Members of the HL Series introduced last year, for example, furnish 1500W. One model, the HL1500, delivers 5V at 300A. All the $960 (100) switcher's critical components—including the power bridge, diode assembly, control electronics and input and output capacitors—are field-replaceable plug-in modules. The control electronics permits remote sensing, ±10% output programming and remote on/off switching.

Another 1500W 5×8-in. box comes from Qualidyne systems. Model 9010 delivers one dc output, ranging from 5V at 275A to 28V at 55A. The unit's transient response limits output deviation to 3% of peak output for a ±25% load change; output recovers to within 1% of

Taking advantage of the efficiencies *available at higher frequencies, Abbott Transistor Labs' Model Z switcher runs at 38 kHz.*

Incompatible MTBF specifications

Dan Ketcham and **Dave Newton,**
Abbott Transistor Labs

Because the costs of a switcher failure go far beyond power-supply replacement cost, OEMs always look for ways to compare estimates of supply reliability.

The most often cited spec is the mean time between failures (MTBF), but you might have problems using this measurement. Incompatibilities can arise if you compare MTBF specs calculated using different versions of the Military Handbook 217 (MIL-HDBK-217) reliability standard.

Now in its third revision (C), this handbook identifies individual component-failure rates. However, any one of the four handbook versions (the original and three revisions) could have supplied the failure rates used to calculate a specific product's MTBF. To properly interpret the reliability value, then, you must know which handbook version was used.

In general, each new version of the standard utilizes more accurate models for component-failure mechanisms and has shortened inflated MTBFs based on the original standard and preceding versions. For example:

- Revision C is the only version that recognizes the weakness of using nonhermetic ICs. It also recognizes the impact of package complexity on MTBF rather than circuit complexity or part-failure rate.
- Rev C penalizes the use of plastic packages, raising the basic failure rate for plastic power transistors, in particular. This version changes temperature-derating rules and decreases quantitative estimates of the effects of applied voltage and quality levels on failure rates.
- Failure rates of commercial metal-film resistors spec 300% higher in Rev C than in B; carbon-film and military metal-film rates are halved. Wire-wound-resistor rates increase by 50%, and all trimming-pot failure rates are substantially lower.
- Dielectric-film-capacitor failure rates rise 1000% in Rev C. Mica parts are considered 500% more prone to failure than before, but the standard lists ceramic units as 90% more reliable. Tantalum failure rates fall 60%. Rev C also provides a capacitance-dependent failure-rate multiplier.
- The latest standard increases all types of magnetics' failure rates 100% and tags commercial-grade parts with an additional 50% increase.

These rating differences can vary a switcher's MTBF by as much as a factor of two, depending on the handbook revision used.

(The authors are managers of corporate marketing and engineering, respectively, at the Burbank, CA-based company.)

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Military will provide the spur for high-frequency designs

its nominal value within 300 μsec. The 16-lb unit costs $875.

If you want a lot of power in one package but need it divided up among several voltages, try the units in Todd Products Corp's SM Series. They furnish 750W, parceled out to as many as four dc voltages. One such supply, the SME, occupies a bit more than 5×8 in., however; it measures $6\frac{7}{8} \times 9\frac{1}{8}$ in.

Generally, the higher you make a supply's switching frequency, the smaller you can make its transformers—a fact that has prompted much research into higher switching frequencies. Such frequencies also reduce problems with radiated noise and help eliminate heat from the magnetics. Today's commercial switchers operate at 20 to 40 kHz, with a few (such as Hewlett-Packard's 50W supply) going up to the 200-kHz stratosphere. But most manufacturers don't feel any pressure to rush into frequencies above 100 kHz.

Switching-power-supply manufacturers

For more information on switching power supplies, contact the following manufacturers directly or circle the appropriate numbers on the Information Retrieval Service card.

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ACDC Electronics
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Acme Electric Corp
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(716) 968-2400
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(714) 634-9211
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Advanced High Voltage Co Inc
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Van Nuys, CA 91402
(213) 997-7222
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Arnold Magnetics
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Culver City, CA 90230
(213) 559-0103
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(612) 560-9300
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(213) 539-6320
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Calex Manufacturing Co Inc
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Pleasant Hill, CA 94523
(415) 932-3911
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Newbury Park, CA 91320
(213) 991-1168
Circle No 384

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(603) 623-8885
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Century Electronics
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Culver City, CA 90230
(213) 870-1083
Circle No 386

Computer Power Systems
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(213) 515-6566
Circle No 387

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Cupertino, CA 95014
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Circle No 389

Converter Concepts Inc
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Pardeeville, WI 53954
(608) 429-2144
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Mansfield, MA 02048
(617) 339-9341
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North Wales, PA 19454
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Phone local office
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(617) 332-7350
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Lambda Electronics
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Melville, NY 11747
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At Abbott Transistor Laboratories, for instance, a development team started out to design a 30-kHz switcher and moved up to 38 kHz before becoming satisfied with its performance. The resulting $215 Model Z measures 6×4×2.25 in. and comes in 14 versions that furnish 100W at 3 to 30V dc. Abbott applies the catch phrase "2W per cubic in." to the units.

Because power density is the name of the game for switchers, what's holding back even higher frequencies? The magnetics pose one problem. Although transformers characterized at 200 kHz have been specified for more than 2 yrs, few transformer manufacturers will carry them in stock until demand increases; the parts thus sell at premium prices.

Power-loss problems also affect the move to higher switching frequencies. If a supply's transistor switching losses (including its voltage-control circuits) remain constant in every cycle, as you raise the switching frequency, the losses increase also. Thus, Sierracin's Lauchner estimates that raising the switching frequency by an order of magnitude reduces a unit's size and weight by only 10 to 20%, and the cost goes up, too. ACDC's Hirschberg agrees and remarks that such a price increase completely offsets the size benefit.

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Keep FCC EMI rules in mind when shopping for a switcher

Because of the pricing drawback and because a supply's switching frequency doesn't directly affect a host system, there's no demand for switchers with frequencies above 100 kHz—except perhaps for military applications. And in the long run, military money will provide the push that makes high-frequency units economically feasible.

Beware radiated-noise pollution

One area in which switching supplies *have* made great strides is noise control. Switchers used to get a black eye from many OEMs because of the noise they delivered with the dc voltage. Switcher design has come a long way, however, and units such as Powertec's Valuswitcher restrict ripple and noise to 2% p-p.

Today, concern with switcher noise centers on their radiated signals. You'll see many supplies billed as meeting some combination of FCC, UL or VDE specifications. But because this claim is inherently ambiguous and carries many shades of meaning, check with manufacturers to determine its exact meaning for each power supply. Bear in mind that "designed to" doesn't necessarily mean "meets," and "meets" doesn't necessarily mean "approved by."

The problem becomes particularly nasty in the case of the VDE specifications. They cover two types of requirements: those relating to EMI and RFI and those relating to safety. And the safety considerations prove tougher to meet than those of Underwriters Laboratories. If your products never leave the US, though, you needn't bother about VDE specs.

One set of specs that you *should* bear in mind, however, is the FCC rules governing EMI emissions, which go into effect in October. Make sure that when a manufacturer says a supply meets FCC specs, those specs comply with these new rules.

To meet the new FCC requirements, Sierracin has recently redesigned its entire switcher line. If you buy modules or open-frame supplies, however, you'll probably have to tackle the FCC-approval chore yourself. Some power-supply manufacturers can assist more than others, but vendors should at least supply you with a radiation profile for a supply and any assistance needed in designing EMI and RFI filters.

Some manufacturers, such as Lambda, can provide EMI-suppression options for their switchers. The firm's $110 Model M-YXX-1 EMI-suppressing cover, for example, includes filters that permit LY Series switchers to meet MIL-1-6181D conducted-emissions specs; the perforated cover itself minimizes radiated emissions. **EDN**

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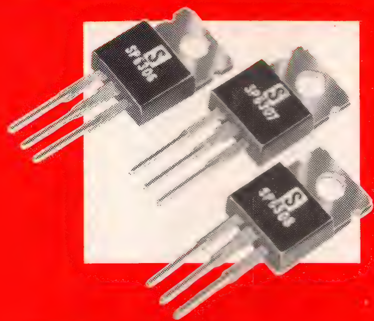

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SP 6308	350	700	8	12/60	4	1.5	3	5	0.4
SP 13006	300	600**	8	8/40	2	1.0	2	5	0.4
SP 13007	400	700**	8	6/30	5	1.5	5	5	0.4

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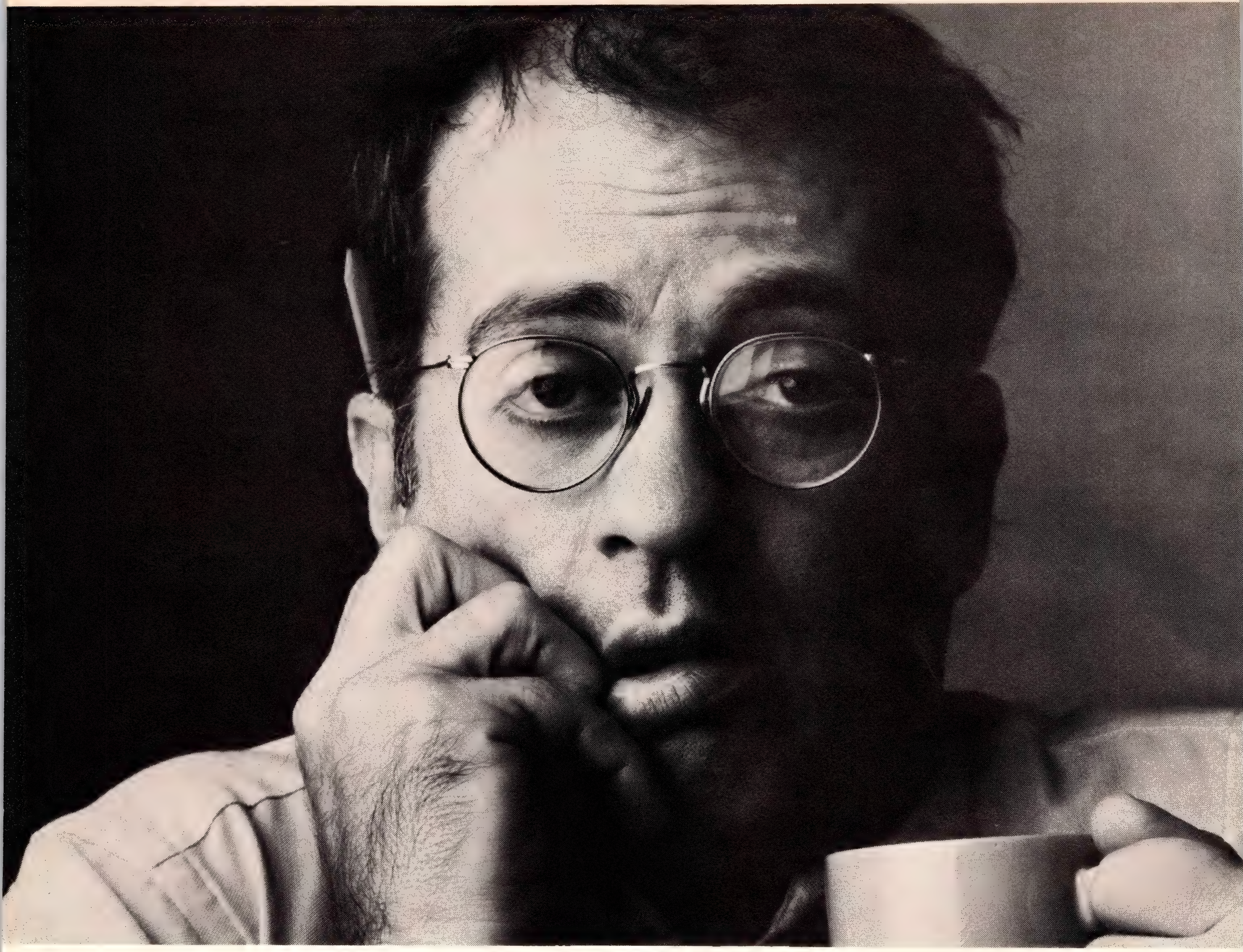

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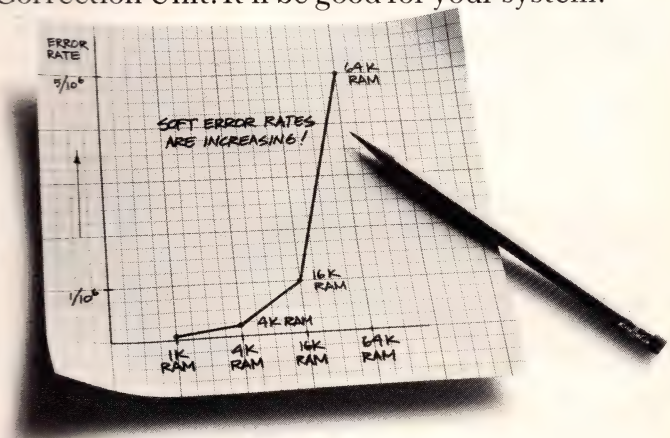

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Simple guidelines for gatherings help you meet with success

If your meetings are boring and unproductive, turn them around. As group leader or participant, you can maximize time spent with colleagues and transform dull meetings into effective forums.

H Kent Baker, The American University

As a technical-staff member, you probably spend many hours each week in meetings with your coworkers discussing the progress you've made on a project or planning the next project phase. When you glance at your calendar and see "meeting, 10 AM," what flashes through your mind? If you envision a boring, fruitless gathering, you're not alone.

Meetings *can* be a bane of professional life—unproductive, frustrating time wasters—but they *needn't* be. Your meetings can come alive and be effective and even enjoyable if you follow a few basic guidelines.

To begin with, face the fact that when you join an organization, you're sentenced to be a "meeting lifer." You'll probably spend a year or more of your working life in meetings—time worth a staggering sum of money. But you needn't serve your entire sentence. You can grant yourself a parole for good behavior; the choice is yours.

Why do meetings fail?

To get the most out of meetings, understand their purpose. Although they come in all shapes and sizes, meetings generally fall into three goal categories: educational, informational and decision-making. Managers, for example, hold meetings to train people, develop teamwork, disseminate information and solve problems—laudable goals, but seldom achieved.

Meetings fail to meet their objectives when the leader and participants don't recognize their roles or understand how to conduct effective meetings. Such problems stem from the lack of a good meeting model. For example, engineers promoted to managerial positions typically base the way they conduct their meetings on those they have attended. If they've never been exposed to a good meeting model, they probably won't conduct productive meetings.

If you've been to more unproductive meetings than useful ones, you, too, must develop an effective meeting model. To do this, recognize how misconceptions about meetings hinder their success.

Dispelling meeting myths

Five myths influence the way people conduct meetings:

- **The success of a meeting depends solely on its leader**—a half-truth at best. A meeting's success is a shared responsibility, as is its leadership. In fact, the leadership role can change hands several times during a meeting. Without cooperation and teamwork, a meeting can degenerate into a wasted effort, a merry-go-round of activity accomplishing little.

All attendees can play a variety of roles to help the group achieve its goals and work together productively. They can perform many task functions, such as seeking and offering opinions and information, clarifying and elaborating on material presented, and summarizing. Additionally, participants perform maintenance functions, including encouraging others to participate, setting and testing standards, limiting conflict, and compromising and negotiating to reduce destructive disagreement. These functions are too numerous and varied for the leader to carry out; all participants must share them.

- **The leader must maintain tight control**—another false assumption. When the leader assumes the role of traffic cop—setting the structure, directing who will speak and limiting discussion—he gets into trouble. That type of "it's my meeting" attitude inhibits dialog and stifles the vitality of free-flowing interaction. This type of leader reduces attendees' functions to reporting only and engages in one-on-one communication without allowing group discussion. Consequently, viewpoints that could be helpful are repressed; a frustrating,

Properly handled conflict is a positive meeting force

unproductive meeting results. Yet such a leader is likely to announce proudly, "I certainly got through that agenda in a hurry."

• **Group participation is necessary in every meeting.** The current emphasis on participation is an overreaction to the very autocratic approach formerly used. For two decades people have heard that truly enlightened managers encourage staff participation. Thus, people tend to believe that participating is productive while observing quietly is harmful. Managers who accept this doctrine without considering the situation often adopt a weak, ineffective management style. On the other hand, the nondirective leader who gives participants free rein almost ensures meeting failure from the start.

A high level of participation is important to some meetings, however. But the leader must be sensitive to the situation, then adopt the most appropriate style; no one leadership style works for all meetings. Sometimes, such as in decision-making meetings, for example, participation is crucial; for others, such as informational meetings, a more directive approach works. Whether the meeting leader prefers a directive, nondirective or something-in-between style, he must recognize that he is the major session catalyst.

• **Avoid conflict at all costs.** Contrary to popular belief, conflict can be a positive force in a meeting if handled properly. For instance, conflict can broaden the understanding of certain problems. Encouraging conflict in problem-solving meetings can help uncover a variety of solutions. Conflict can also stimulate interaction and involvement of meeting participants (see **box,** "How to encourage *constructive* conflict").

• **Everyone should be invited.** Because a large group often slows a meeting's pace, limit the number of people you ask to attend. Touching base with interested parties is a sound idea, but a meeting might not be the place to do so. Don't invite people to a meeting unless you really need them. And if you only require their presence for part of the meeting, schedule a specific time for their arrival. You'll thus avoid having an uninterested person sit through your meeting waiting to be called on.

Follow guidelines selectively

Once you debunk the myths surrounding meetings, you're ready to apply a few meeting guidelines. But consider them selectively to avoid taking a stilted, cookbook approach. Then, when you're asked to lead a meeting, remember these suggestions:

• **Don't hold unnecessary meetings.** The easiest way to reduce the number of meetings you hold is to find other ways to communicate. Reports, memos, telephone conversations and face-to-face discussions, for instance, can serve the same purpose in less time.

Because regularly held meetings often become rituals, consider their value carefully. Sometimes the only reason for holding a staff meeting is because it's Monday. Regularly schedule certain gatherings such as staff meetings only when they will provide a forum for worthwhile communication.

• **Set realistic goals.** Before you call a meeting, know exactly what you want to accomplish. If you don't, the meeting is likely to wander aimlessly from one issue to another. If you're unsure of your objectives, certainly others will also be lost.

Furthermore, make sure that you can accomplish the meeting's objectives within a reasonable amount of time. Meetings tend to diminish in productivity after 1½ hrs. Participants get restless, enthusiasm wanes and the meetings become endurance tests. Lengthy meetings also encourage people to babble on without accomplishing anything worthwhile. When your meeting goals appear too ambitious, hold two meetings separated by at least one day.

• **Don't spring surprises.** Try to circulate a copy of your objectives and agenda before the meeting; if you want people to study background material, send that too. Advance information helps participants come prepared.

• **Avoid catching people off guard.** If you save a touchy subject for the meeting and spring it unannounced on your colleagues, they might resent your tactics, and their hostility could diminish your effectiveness as a leader. Therefore, if you expect your group to contribute its best efforts, provide it with a sufficiently detailed agenda a few days before you meet. And to

How to encourage *constructive* conflict

Conflict can actually make a meeting more productive when the leader ensures that it helps develop solutions and doesn't just fuel disagreements for the sake of arguing. To monitor conflicts at your next meeting, heed some simple advice:

• **Agree to disagree**—Emphasize that it's acceptable to express views contrary to the prevailing opinion. Encourage those with differing opinions or original ideas to speak up.

• **Stress noncombative disagreement**—Remind the meeting participants that disagreement isn't intended to produce winners or losers but rather to improve their understanding of the problem at hand.

• **Create a supportive atmosphere**—Support each participant's right to disagree and express his opinion. Because a strong faction might attempt to intimidate an individual with an unpopular opinion, ensure that anyone who wishes to speak gets the group's attention.

• **Focus on issues, not personalities**—Establish the ground rule that participants can disagree on an issue, but they can't attack the people who express opinions on it.

further avoid surprises, you can make notations next to each agenda item to alert participants about how you expect them to contribute to the meeting.

- **Set the proper climate.** A good meeting environment won't ensure that the meeting will run smoothly, but uncomfortable surroundings, poor lighting and interruptions will certainly make concentration difficult. Monitor the participants' feelings during a session. When their interest and energy have dissipated, don't drone on just to cover the agenda; if you do, you'll accomplish little. Notice signs that indicate changing energy levels—tone of voice, loudness of speech, body posture, fidgeting and doodling. Recognize them and act appropriately—take a short break, change the pace or just tell a joke.

You can also foster a supportive atmosphere by encouraging cooperation rather than competition among participants. And try to prevent anyone from monopolizing the discussion. One of your responsibilities as leader is to ensure that each member has the opportunity to speak. A useful technique is to seek the opinions of junior members before those with senior status speak. By drawing junior members into the discussion, you emphasize their right to contribute and might hear ideas that would not otherwise be offered.

- **Summarize.** By making frequent summaries during the session, you can note the meeting's progress and point out any disagreements that the group should straighten out. At the meeting's close, review conclusions reached, major disagreements still unresolved and steps to be taken so that participants clearly understand what the meeting has accomplished.
- **Finally, follow up.** As a leader, you carry a responsibility that extends beyond the actual meeting. To fulfill it, send a written summary to the meeting attendees and others who need to know what the group decided and what action it will take. Because attendees tend to forget what happened at a meeting, send the minutes the day of the meeting if possible. Lastly, ensure that those who have agreed to take action carry it out as the group mandated.

Participants have a job, too

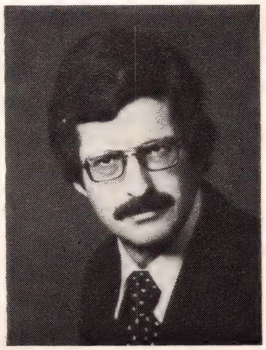
These guidelines demonstrate how a group leader can set a meeting's tone and influence its productivity. Yet participants, too, can contribute to a meeting's success. As a participant, consider these guidelines:

- **Be prepared.** Lack of preparation wastes time and leads to confusion and frustration. People who prepare or rehearse their reports during a meeting distract and annoy others and minimize their own potential contributions.
- **Insist on starting and ending on time.** Question a leader who wants to postpone the meeting's start for latecomers. Point out that such action penalizes those who come on time and actually rewards those who arrive late. And if the meeting runs on for an unreasonably long time, remind the leader that the participants have other commitments, and suggest adjourning.
- **Don't bring a hidden agenda.** Try not to digress too far from the scheduled agenda. And if others do, try to refocus the group's attention to the items it has met to discuss.
- **Demand excellence.** If you are tired of attending ineffective meetings, constructively make your feelings known. Propose a meeting audit where participants record suggestions for improvement. Collect their lists and discuss them. You might find that you aren't the only one who's disappointed in the way the group has been conducting meetings.

Finally, remember that the guidelines offered here are useless until you apply them. If you've been tolerating unproductive meetings, you are part of the problem. But if you follow these simple suggestions, you can lift your meetings out of the doldrums.

Incidentally, it's time for that 10 AM meeting. Are you ready for it? **EDN**

Author's biography



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Article Interest Quotient (Circle One)
High **470** ***Medium*** **471** ***Low*** **472**

NEXT TIME

Look for a Special Report on high-frequency instruments in EDN's February 18 issue. You'll also find articles on

- The use of S/H amplifiers as circuit components
- The design of effective EMI and RFI shielding

. . . and much more. Also look for news stories on the latest benchtop testers and on "standards" that sometimes aren't, plus our regular μC Design Techniques, Design Ideas and A Question of Law departments. You can't afford to miss this issue!

EDN: Everything Designers Need

Extend your design options with a new comparator IC

More than an over/undervoltage protector, a recently introduced multicomparator IC combines programmable hysteresis with dual high-current outputs. Applications range from ac-mains-loss monitoring to dual-channel proportional control.

William F Davis, Motorola Inc

Circuit designers familiar with ICs employed in power-supply-type voltage-monitoring and fault-detection applications usually cite lack of versatility as those devices' major limitation. The MC3424, a monolithic dual-channel high-output-current voltage comparator, overcomes this lack of flexibility in monitoring and fault-detection designs. And it's versatile enough to meet many of your other design needs, too. The device achieves this capability by incorporating features and options not usually found in other comparator ICs (see **box,** "An uncommon comparator").

The problems with conventional ICs

Traditional fault-monitoring ICs often provide only the inverting or noninverting input of a comparator, with perhaps a small amount of internal hysteresis. And what's worse, that comparator might be referenced to

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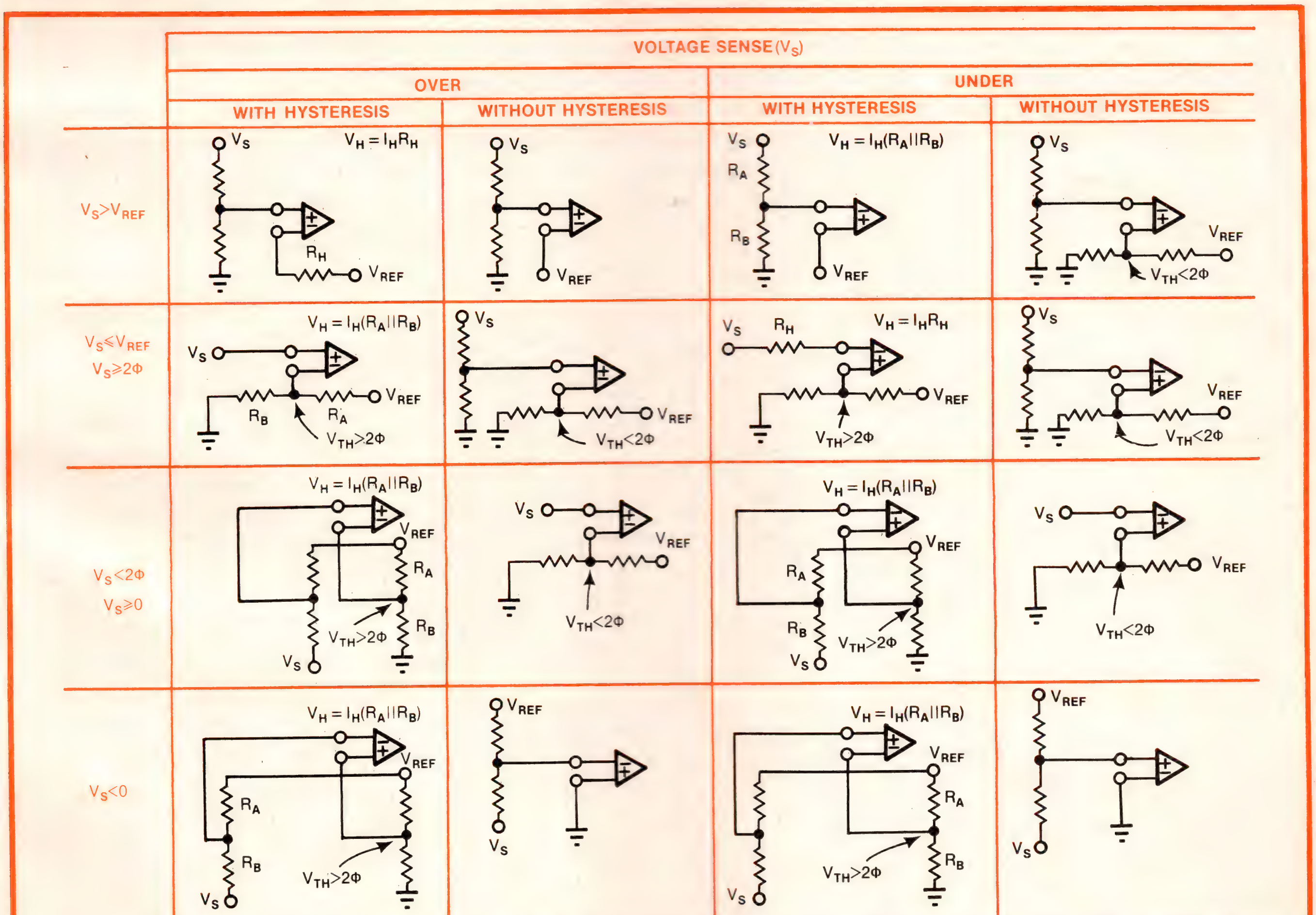


Fig 1—All voltage-sensing functions *possible with the MC3424 appear in this chart. Determine whether the sensed voltage (V_S) is positive or negative, whether it's greater or less than the reference (V_{REF}) and whether hysteresis is required. Then find the diagram satisfying these constraints and apply the indicated resistor ratios.*

An uncommon comparator

The MC3424—a high-current dual-channel voltage comparator—incorporates the two separate and independent channels shown in **Fig A.** Capable of operating over a 4.5 to 40V supply range and over −55 to +125°C, each channel includes a fully differential input voltage comparator (comparators 1 and 2) with programmable hysteresis capability and a delay filter terminal (DLY) at its output.

The voltage at this filter point goes to an output comparator internally referenced to the 2.5V reference (V_{REF}). This comparator drives the output power devices to a source-current limit of 300 mA at the DRV pin and an indicator-output current sink of 30 mA at the IO pin.

A TTL LOW at the remote activation ($\overline{RA}$) input overrides the input comparator and its associated time delay at any time and turns the output power devices on. A similar LOW at the Input Enable (IE) pin disables one or both of the input comparators. Under these conditions, input-comparator outputs can't occur, regardless of the input state.

You can disable both channels when the noninverting input (C_1^+) of input comparator 1 is less than $0.9V_{REF}$ and the IE voltage is LOW. Otherwise, IE disables only input comparator 2.

The device's laser-trimmed voltage reference (V_{REF}) is adjusted to within ±1% of 2.5V, has a temperature coefficient of approximately 50 ppm/°C and can deliver load currents up to 10 mA.

Note several important points regarding the MC3424's input-comparator circuitry, shown in **Fig B.** In both of the input comparators, the differential inputs are externally available and can handle a common-mode range of $V_{CC}-1.4V$ including ground. Thus, you can reference these comparators to virtually any reference voltage within the common-mode range.

Whenever the noninverting input (C^+) exceeds the inverting input (C^-), an internally generated hysteresis sink current (I_H) appears at the inverting input. Placing any resistance R in series with the inverting input then produces a hysteresis voltage equal to I_HR volts (I_H is typically 12 μA).

If, however, the inverting-input voltage is less than two forward-biased diode drops ($2\Phi \simeq 1V$ at 25°C), the internally activated hysteresis current can't appear at the inverting input because it can't flow through diodes biased below their conduction level. Thus, for this particular case, hysteresis isn't generated with resistance in the inverting input.

Because of the inherent high-voltage junctions incorporated in this comparator, an input-voltage differential of ±40V is permissible. The diodes placed within the comparator also allow both inputs to exceed the supply voltage without detrimental effects on the adjacent channel. Furthermore, they aid in reducing the comparator's large-signal delay to less than 200 nsec.

By attaching a capacitor to the comparator-output Delay pin (DLY), you can obtain a fixed time delay before the capacitor is charged by the internally generated current (I_O) to the output comparator's reference voltage.

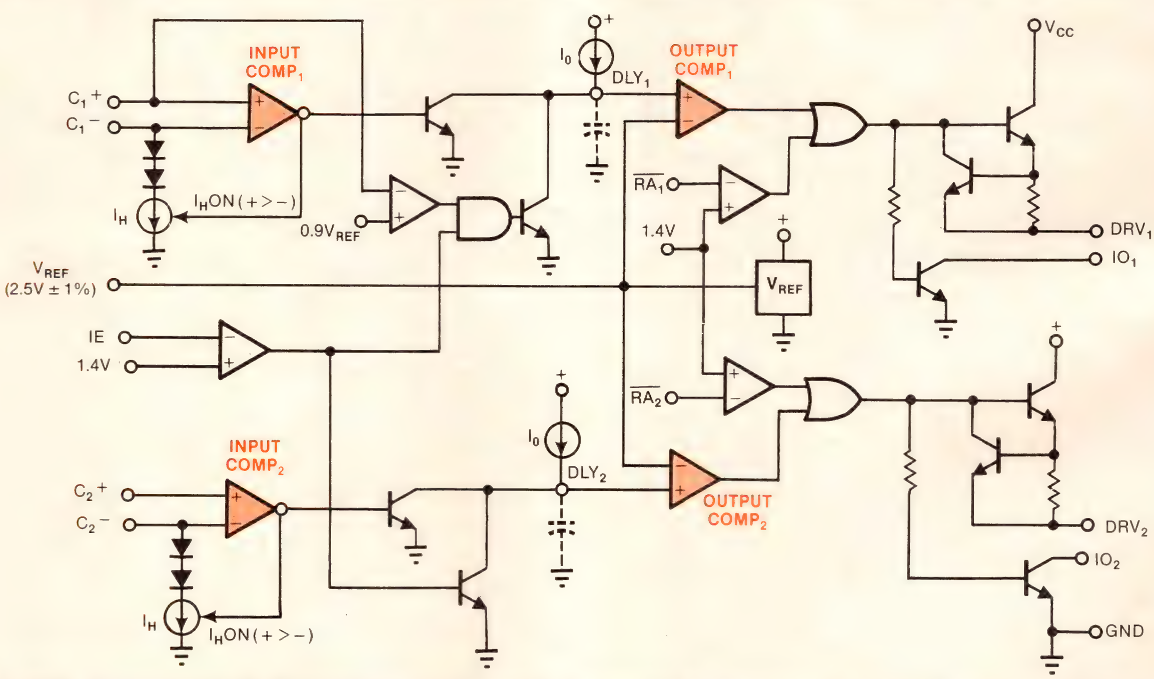


Fig A—Both channels of the MC3424 voltage-comparator IC *appear in this functional circuit diagram. The device incorporates such extra functions as Input Enable (IE), Remote Activation ($\overline{RA}$), Delay (DLY) and hysteresis control on the input comparators' inverting inputs. The dual outputs (DRV) can each source as much as 300 mA, and the indicator outputs (I0) each can sink up to 30 mA.*

This delay time is given by $T_d = CV_{REF}/I_O$, where I_O is approximately 200 μA.

The MC3424's modified bandgap voltage reference **(Fig C)** employs one additional small-value resistor (R_A) in the unit-area device's emitter. This construction reduces the amplifier's transconductance (g_m) without lowering its current. Large-value resistors for R_B and R_C would normally be required for g_m reduction by a more classical approach.

This g_m reduction allows you to capacitively load the band-gap reference with a wide range of values. You can thus improve the regulator's high-frequency-transient performance without degrading its stability.

Resistors R_A and R_B are laser trimmed to provide the reference voltage's initial ±1% tolerance and ensure a typical TC of 50 ppm/°C. This precision allows you to more accurately define your voltage-sense limits in production without tweaking.

The basic MC3424 output circuitry shown in **Fig D** demonstrates the solution to a problem that other circuits of this type suffer. Although you would like the output drive to be OFF (ie, the output comparator holding transistors Q_2 and Q_3 OFF), a rapid V_{CC} rise can cause the parasitic capacitance at Q_1's base and Q_5's collector-base junction to generate displacement currents (I_B and I_{CB}), which then enter node A.

If transistor Q_4 is OFF, this parasitic current drives the base of the Darlington output device and creates a spurious output. In the MC3424, though, transistor Q_4 is turned on through resistor R, sinking the displacement current when the supply has risen above approximately 0.7V. This technique permits supply turn-on voltage dv/dt to exceed 200V/μsec before 1 mA of parasitic output drive current is generated.

For a data sheet on the MC3424, **Circle No 449.**

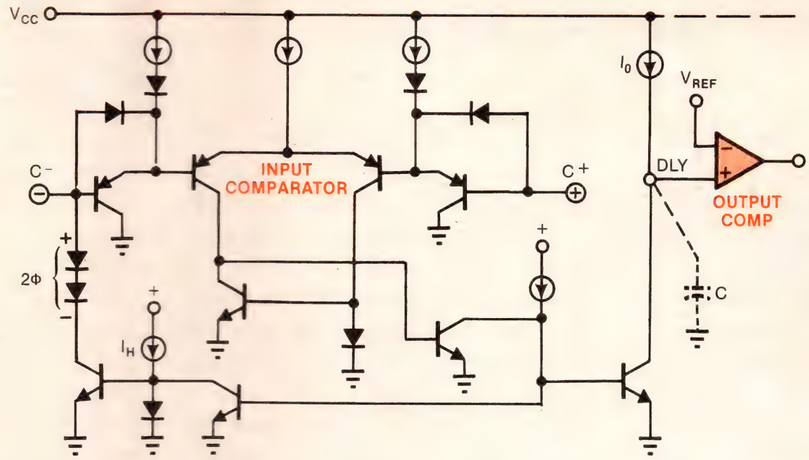


Fig B—Programmable input hysteresis *results from controlling the current flow through the MC3424's inverting inputs' diodes. Tying an external resistor (R_H) to each inverting input generates a hysteresis voltage equal to the diode current (typically 12 μA) times the resistance value.*

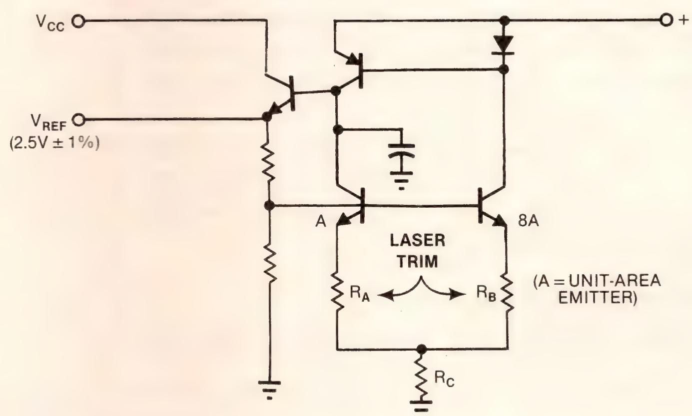


Fig C—The MC3424's on-chip 2.5V band-gap voltage reference *can supply as much as 10 mA to the outside world. The additional resistor R_A reduces the amplifier's g_m and stabilizes the amplifier against high capacitive loading.*

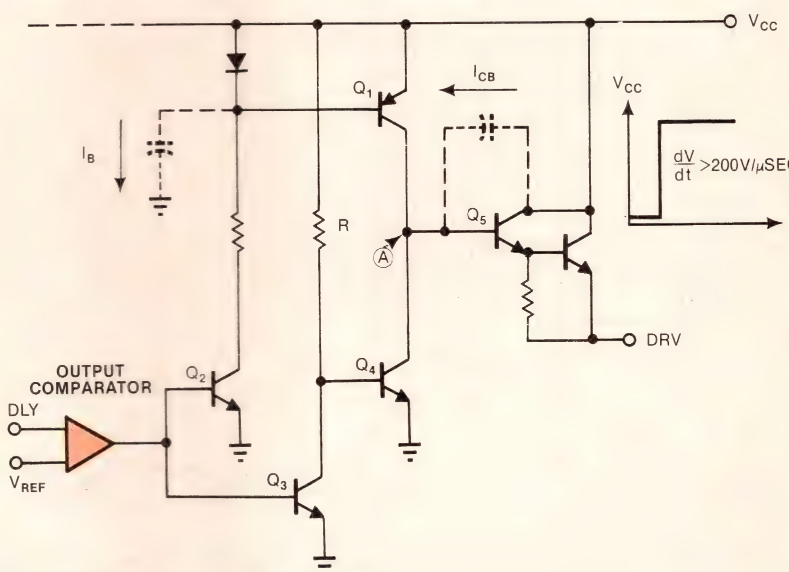


Fig D—Spurious output pulses can't occur *with this design—even when the supply voltage first turns on. Here, Q_4 turns on as soon as the supply exceeds 0.7V—an action that shunts the displacement currents I_B and I_{CB} to ground.*

Programmable hysteresis simplifies tight voltage comparisons

an internally generated untrimmed voltage. This arrangement tends to constrain usage to one particular application type; ie, always sensing over/undervoltages above the reference. And for single-positive-supply operation, this limitation automatically excludes all negative voltages. You might also be unable to easily disable any one of the input functions for a specified time interval or adjust the input hysteresis to satisfy some particular input-noise requirement.

An especially troublesome situation occurs when the on-chip reference voltage isn't available for external use; you can't employ this voltage as a system reference throughout your design. And if it's available but untrimmed, you often must trim all of the design's level-shifting resistors. Additionally, some power-supply-monitoring ICs have output-current capability too low to directly drive high-power transistors or SCR crowbars. Conversely, it's not unusual for some device types to produce a spurious high-current output pulse when the supply voltage first turns on.

All of these drawbacks are designed out of the MC3424. The result? A device capable of wide-ranging applications, not the least of which are supply monitoring and fault detection.

Fault finding made easy

Even when operating with one supply voltage, each of the MC3424's input comparators can sense either overvoltages or undervoltages for all positive and negative values greater or less than the reference. And this sensing can occur with or without programmable hysteresis. Hence, you can implement all of the possible input-comparator configurations depicted in **Fig 1** without using additional devices.

Consider a power-supply supervisory function, for example. Assume you want to monitor two separate and independent supplies for overvoltage faults: one at 15V with hysteresis, the other at −15V without hysteresis. You can arrange the supervisory circuitry so that when either supply reaches an overvoltage level for more than a specified time, an SCR crowbar blows its fuse and the appropriate indicator turns on.

However, because both supplies can shut down

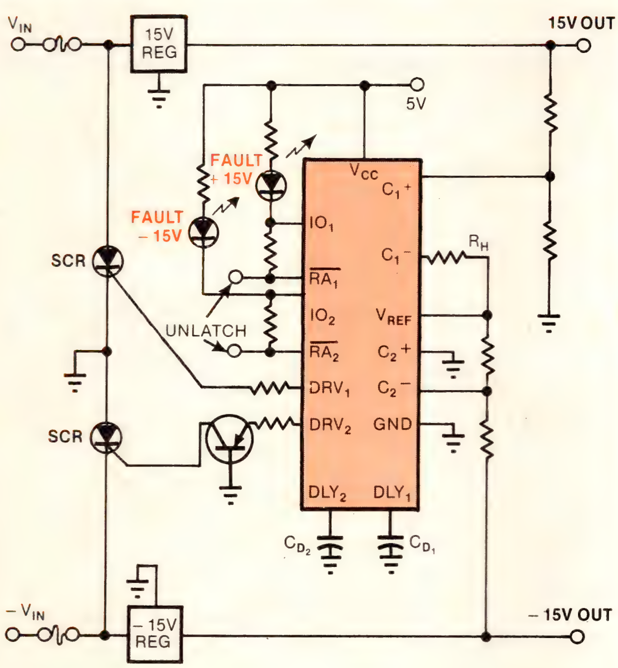


Fig 2—Fault-protecting two separate supplies *is easy with the MC3424. If either 15V supply faults, the IC senses the condition and crowbars the appropriate SCR and fuse. The 5V supply is necessary only if continuous LED fault indication is important.*

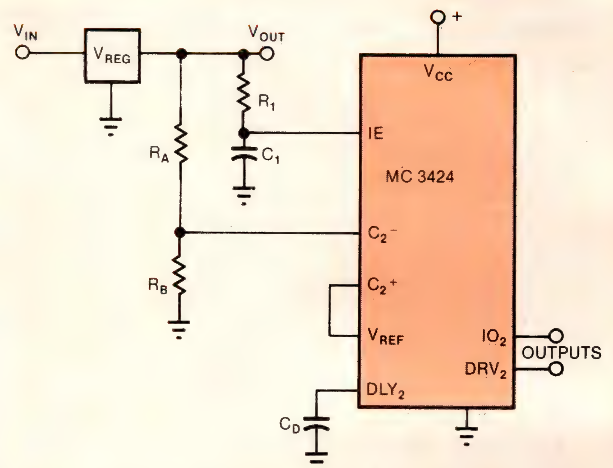


Fig 3—Without its input-enable option, *the MC3424 would falsely sense a too-low voltage in this undervoltage detector during power-up. But when you connect the IC as shown, the IE input disables the C^- sense input until C_1 charges up to threshold.*

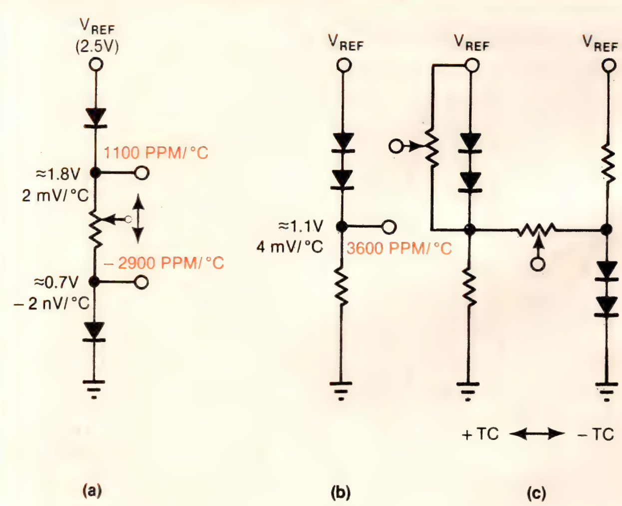


Fig 4—Obtain positive and negative TCs *from the MC3424's sense-reference level with the scheme shown in* **(a).** *A larger (but fixed) positive TC results with the circuit in* **(b),** *and* **(c)** *provides a method of achieving variable positive or negative values.*

simultaneously, in this case you should power the MC3424 from a third supply to activate the desired indication. Also, you must latch the appropriate output ON once the overvoltage occurs, because the crowbar removes the overvoltage condition. Achieve this latching capability merely by connecting the IC's Indicator Output pin (IO) to the Remote Activation input ($\overline{RA}$) through a resistor (**Fig 2**). Then, during an overvoltage, the IO pin is pulled to ground, holding $\overline{RA}$ below the TTL threshold and latching both outputs of that channel ON, regardless of subsequent input conditions. You can unlatch the output by pulling $\overline{RA}$ above the TTL input threshold.

Adjust the input hysteresis for the positive-voltage sensing by varying the $I_H R_H$ product, and select the delay capacitors (C_{D_1} and C_{D_2}) to meet your specified time-delay requirements. The gate and indicator output resistors serve to force the high-current outputs into

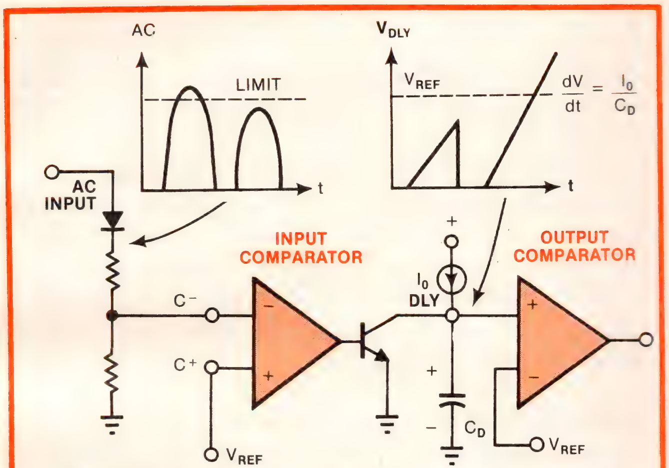


Fig 5—AC-power-line monitoring *can occur on a cycle-by-cycle basis with the MC3424. If the peak ac input doesn't exceed a predetermined limit, capacitor C_D charges to the output comparator's reference level, and a fault output results.*

saturation, minimizing chip power dissipation in the Output Latched mode.

Fig 3 demonstrates how you can employ input comparator 2 of the MC3424 to sense undervoltage conditions with hysteresis. Choose the R_1C_1 product to ensure that the sensed supply's undervoltage condition during power-up is not reported; to accomplish this function, C_1 holds the high-impedance Input Enable pin (IE) below its TTL threshold. Resistor R_1 subsequently charges C_1 past the IE threshold and permits undervoltage monitoring of the sensed supply after that supply reaches its normal operating range.

Hysteresis magnitude is determined by the $I_H(R_A||R_B)$ product, and internal charge current I_O and capacitor C_D control comparator output delay. Note that input comparator 1 isn't disabled when input comparator 2 is unless the noninverting input (C_1^+) is less than $0.9V_{REF}$. Because the comparators have an input common-mode range spanning $V_{CC}-1.4V$, you can easily monitor *relative* voltages. Voltage V_1, for example, can be checked to see whether it's always greater than V_2; likewise for V_3 greater than V_4. Similarly, you can sense whether $V_1 > V_2 > V_3$. And should a voltage lie outside the IC's common-mode range, you can use resistive scaling to bring it within that range.

Track the sensed voltages' TC

Sometimes a sensed voltage has a well-defined temperature coefficient that you'd like to track. Several possibilities exist for generating both positive and negative TCs when you use the MC3424's reference voltage in conjunction with some external forward-biased silicon diodes.

Such diodes—with a TC of approximately −2 mV/°C—can connect to the IC's zero-TC V_{REF} pin to achieve an overall positive TC, a technique depicted in

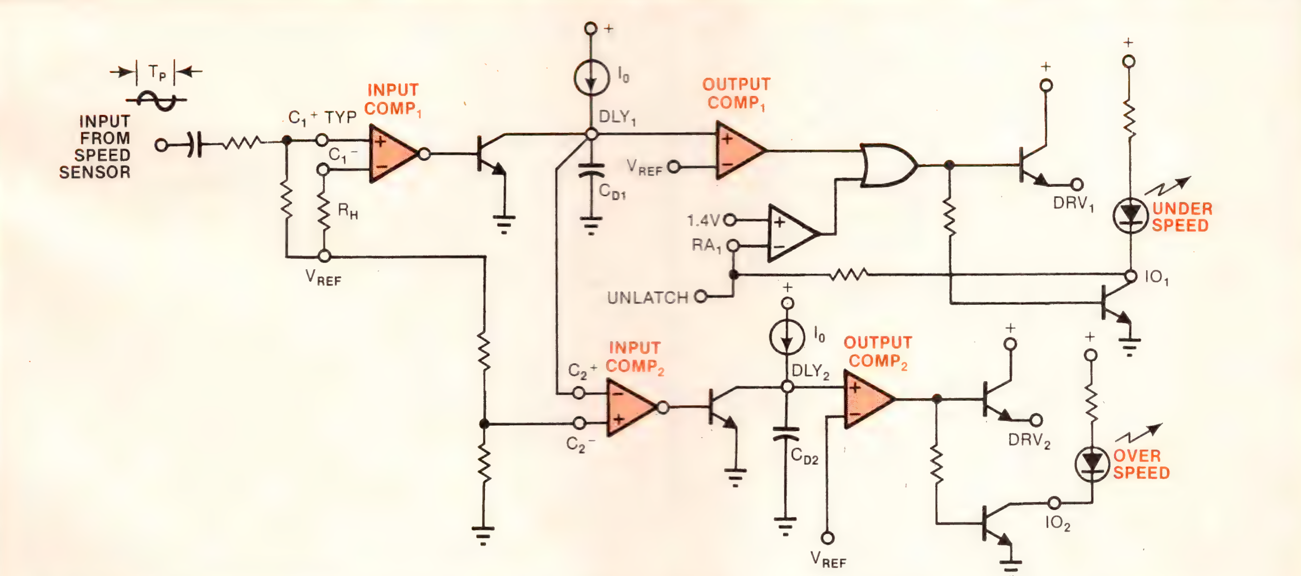


Fig 6—Over/underspeed conditions are sensed *and flagged when one MC3424 comparator works as a zero-crossing detector and the second functions as a variable-threshold detector. So long as the input-signal period (T_P) falls within the time windows set by C_{D_1} and C_{D_2}, neither LED lights.*

Fig 4a. And you can realize larger positive TCs by using the scheme shown in **Fig 4b,** incrementally adjusting those TCs with the method detailed in **Fig 4c.** Finally, you can easily realize negative TCs by connecting the off-chip diodes to ground.

Monitor the mains

The MC3424-based ac-mains monitor shown in **Fig 5** can sense a low ac-mains voltage occurring for any specified number of cycles. When the ac voltage is below the defined limit for that number of cycles, the MC3424's input comparator allows the delay capacitor to charge at a dv/dt determined by I_O/C_D.

If the next cycle's most positive peak exceeds the limit, the comparator's output pulls the capacitor's accumulated voltage back toward ground. However, if the next cycle's peak doesn't exceed the limit, C_D continues to ramp up at the same uninterrupted rate. By selecting the appropriate value for C_D, you can determine how many cycles the circuit can miss before C_D's voltage reaches the output comparator's V_{REF} threshold and triggers an output response.

Sequential turn-ons are possible

In another MC3424 application, you can interconnect one channel's IO pin with the other's $\overline{RA}$ or Delay (DLY) terminal and realize a sequential activation sequence. For example, if you hook up channel 1's IO pin to channel 2's $\overline{RA}$ input, channel 1 triggers channel 2's output, but 2 won't activate 1's output. Alternatively, if you couple channel 1's IO to channel 2's DLY input so that 1's output holds DLY LOW, a channel 1 output inhibits a channel 2 output without the converse condition being possible. Consider what other possibilities exist if you permit interaction to occur with the IE pin.

You can also generate sequential time delays. Connect the input comparators to a common input signal; by selecting different delay-capacitor values, you can then produce different time delays for each channel—with repeatability limited only by the capacitors' tolerances and TCs. Independent high-current outputs then occur after a fixed time interval from the input's transition.

Try a 2-input, variable-threshold AND

By connecting channels 1 and 2's DLY pins together, you can obtain a 2-input, variable-threshold AND function, with or without delay. If you also connect the drive and indicator outputs together, you double the minimum drive and indicator output currents to 600 and 60 mA, respectively. Furthermore, by making use of the IE function's TTL threshold, you can create a 3-input AND gate.

You can also realize an OR gate. Connecting channel 2's indicator outputs together accomplishes half the job; you must also OR the drive outputs with a pair of off-chip diodes capable of handling the 300-mA current levels. Connect each diode's anode to the individual channel's outputs and obtain the ORed output at the common-cathode point.

Over/underspeed indicator works continuously

The indicator depicted in **Fig 6** demonstrates how you can use one comparator in the MC3424 as a zero-crossing detector with hysteresis while the other acts as a variable-threshold detector. Here the object is to

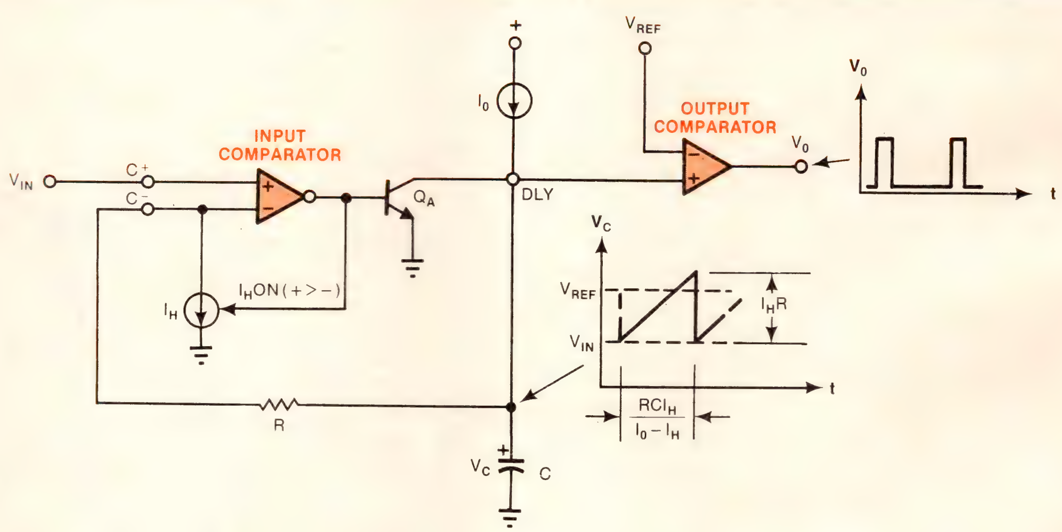


Fig 7—Implement either a fixed-frequency sawtooth *or a voltage-controlled pulse-width modulator with this design. When V_{IN} is constant, the sawtooth's period is determined only by the relationship shown. But when you modulate V_{IN}, the varying point at which the sawtooth's peak exceeds the reference voltage determines the output pulse's width.*

latch an indicator ON when an underspeed situation occurs and continuously indicate overspeed conditions.

Assume the ac input (with period T_P) comes from a speed sensor. Set input comparator 1 to switch with a hysteresis voltage of $I_H R_H$ for any positive-input zero crossings. Under these constraints, C_{D_1} ramps to a voltage of $I_O T_P/2C_{D_1}$ before the negative-going input cycle pulls the capacitor back toward ground. At speeds below the desired limit, the capacitor's voltage exceeds not only output comparator 1's threshold, but also input comparator 2's during the positive-going input interval ($T_P/2$).

This action clamps the DLY_2 voltage to ground and turns channel 1's outputs on. And because channel 1's IO pin connects to the $\overline{RA}$ pin, the output latches up and indicates that an underspeed condition has occurred. During the negative-going input cycle, DLY_1's voltage clamps to ground, and DLY_2's voltage is allowed to rise. Choose C_{D_2} for worst-case minimum speed, however, so that DLY_2's voltage can't reach output comparator 2's V_{REF} threshold before the next positive input occurs.

When the speed increases to the design range, DLY_1's voltage doesn't reach output comparator 1's threshold but does continue to exceed input comparator 2's, thereby always resetting C_{D_2}. This action allows channel 1 to unlatch if $\overline{RA}_1$'s input voltage gets pulled above the TTL threshold. Thus, both outputs remain OFF when the input speed lies within range. At speeds above the design limit, C_{D_1}'s voltage remains below the thresholds of both input comparator 2 and output comparator 1. Channel 1's output is OFF and C_{D_2} charges beyond output comparator 2's threshold, producing a continuous channel 2 output so long as the input frequency (speed) exceeds the upper limit.

RC oscillators are simple and stable

Fig 7 shows an interesting method for using an MC3424 to create an RC relaxation oscillator. The design employs one resistor, one capacitor and an input comparator. Assume that the delay capacitor's voltage has just decreased past the input voltage V_{IN} (due to the IC's pull-down current of transistor Q_A). This action activates the hysteresis current and produces an $I_H R$ voltage differential at the comparator's input. The internal pull-down current switches off, and the delay-capacitor voltage begins to rise at dv/dt equal to $(I_O-I_H)/C$. When this voltage reaches $I_H R$, the input comparator's voltage changes sign and switches the hysteresis current off. The internal pull-down current again switches on, causing the capacitor's voltage to decrease until the comparator again switches and repeats the cycle. Thus, the sawtooth waveform's magnitude is $I_H R$, and its period equals $RCI_H/(I_O-I_H)$. Note that because I_H/I_O is reasonably constant over temperature, supply-voltage and processing variations, you can tightly control the oscillator's frequency through RC selection alone.

Fig 7's design lends itself to pulse-width-modulation schemes, too. In those cases, an analog input signal (V_{IN}) modulates the output pulse's width but not its oscillation frequency. The output pulse is ON for the time during which the sawtooth's peak exceeds the output comparator's threshold. Applications for this class of proportional controller include switching regulators, motor controllers and thermal regulators.

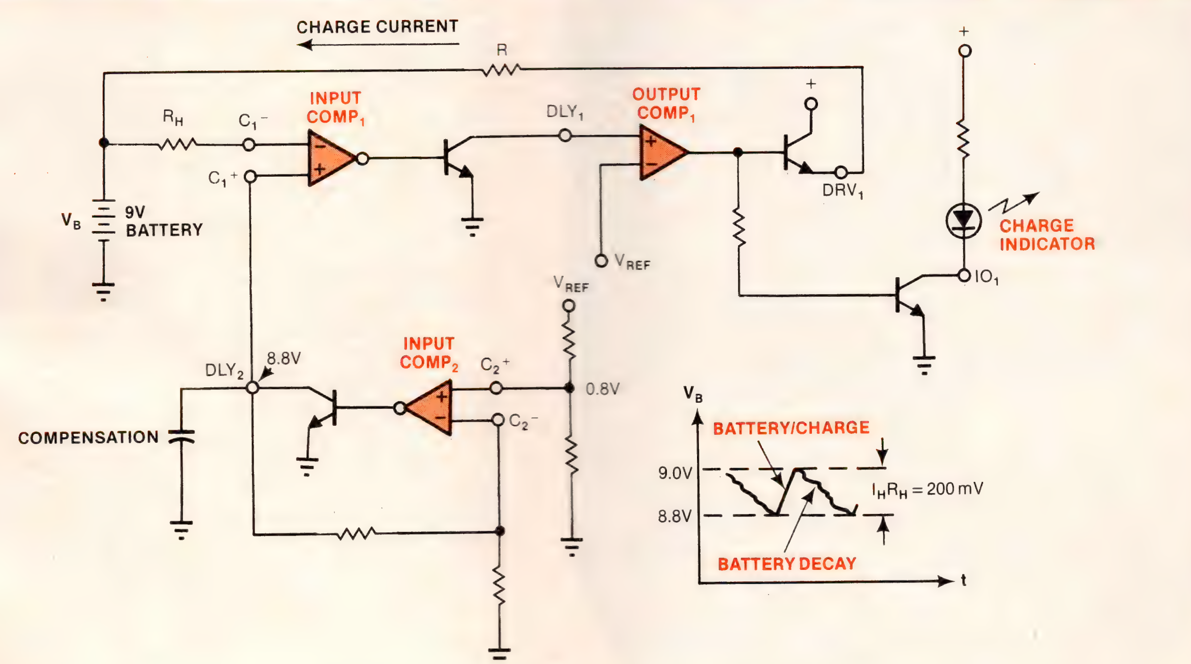


Fig 8—Battery charging occurs *when the MC3424's input comparator 1 senses that the battery's voltage has dropped below the combined 8.8V reference and 200-mV hysteresis voltage. Comparator 2—here used as an op amp—raises the on-chip reference to 8.8V. Because the IC can use any supply voltage between 4.5 and 40V, you can adapt this design to any requirement so long as the 300-mA max charge-current limit isn't exceeded.*

Built in delay functions suppress power-up false triggering

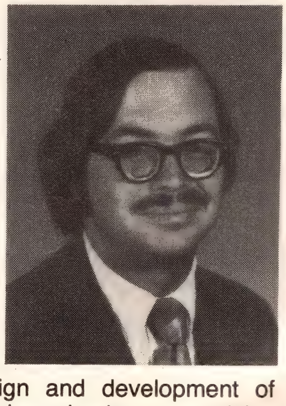
Charge a battery with one IC

As a final example, the battery-sense and-charger design detailed in **Fig 8** exploits the MC3424's input comparators as op amps. Here, you scale up the on-chip reference voltage to 8.8V by applying feedback around comparator 2. (Note that you must keep the input voltage to the op amp below the hysteresis-threshold level to eliminate the positive-hysteresis loop's oscillatory tendencies.)

Comparator 1 uses this 8.8V level as the reference on its noninverting input and senses the battery's voltage through its inverting input. The base current of the input pnp transistor associated with the inverting input, although small, actually tries to charge the battery in the Sense mode rather than discharge it. Hence, this design (unlike others) offers true "no-load" battery-monitoring capability.

When the battery voltage falls below the 8.8V reference, comparator 1 turns the hysteresis current and outputs on. The output charges the battery at a current rate limited by resistor R until the battery's voltage equals 8.8V plus the 200 mV $I_H R$ hysteresis voltage. (Eliminating R allows you to achieve a 300-mA rate.) Then comparator 1 again switches and turns off the charge cycle and LED indicator. **EDN**

Author's biography



William Davis, a senior member of the technical staff at Motorola's Semiconductor Div, Mesa, AZ, has made a specialty of integrated-circuit design. Within a year of earning his BSEE degree at the University of Arizona (Tucson), he became a project engineer in the firm's Linear-IC Research and Development Group. In this position, he concentrated on the design and development of medium-power ICs, with special emphasis on monolithic voltage regulators. From there, he became engineering design manager of a consumer-oriented IC group, where he worked on automotive-IC designs and initiated Motorola's linear-I^2L efforts. Bill's interests now lie in the design and development of industrial ICs, and he has completed the course work for an MS degree at Arizona State University (Tempe). He holds 27 patents in the IC field and has authored several related papers.

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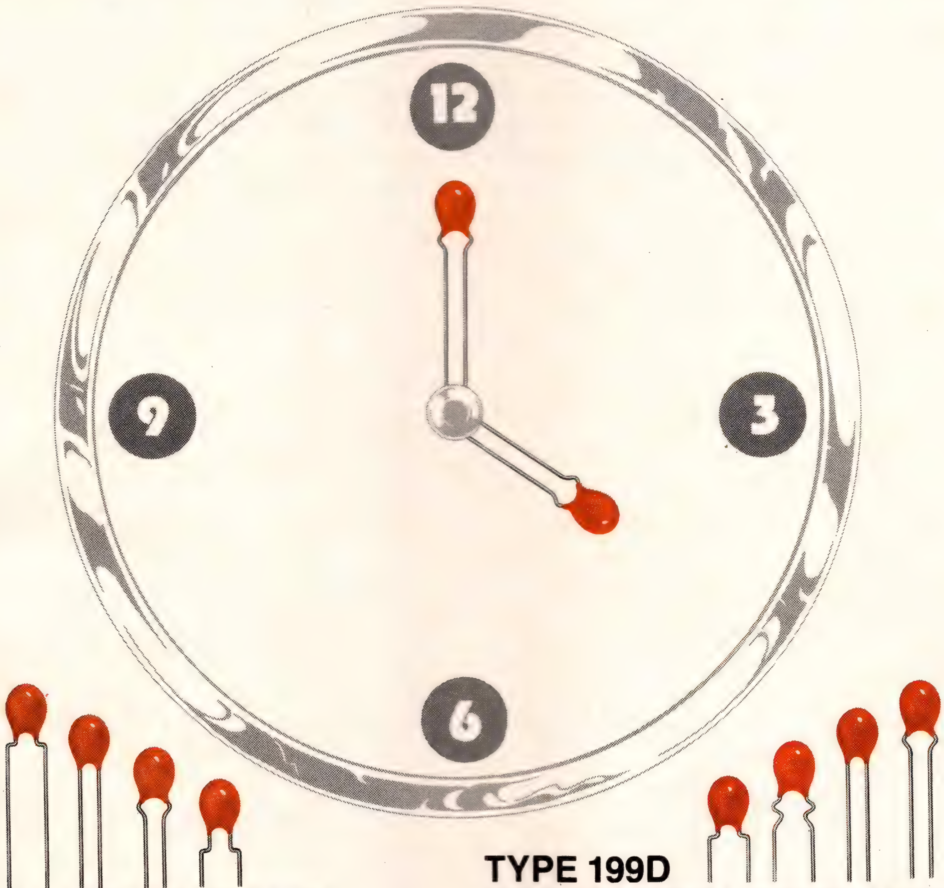

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Network-analysis program runs on small computer system

Edward Niemeyer, Intel Corp

You can analyze a large number of network-element types by running the program discussed in this article on a Hewlett-Packard HP 9825 desktop computer. With memory requirements of approximately 13k bytes, it favors network-data storage over program-memory requirements—a plus in small computer systems.

Based on Schnider's algorithm (**Ref 1**), which uses the indefinite admittance matrix to solve network problems, the program (**Fig 1**) handles both passive and active network elements and even accommodates transmission-line analysis. It's written in HPL, but if an HP 9825 is not available, you can easily translate this BASIC-like language into forms suitable for use on alternative computers.

```
0: "NET*80":dim A[10,10],B[10,10],P[10,10],Q[10,10],R[10,10]
1: dim S[10,10],I[20]
2: dim T[20],M[20],N[20],O[20],L[20],Z[20]
3: 1→J
4: 1→I
5: 0→P[I,J]
6: 0→Q[I,J]
7: 0→R[I,J]
8: 0→S[I,J]
9: if I<10;I+1→I;gto 5
10: J+1→J;if J<11;gto 4
11: 1→X;0→T[X]
12: 0→N
13: prt "1  RESISTOR"
14: prt "2  CAPACITOR"
15: prt "3  INDUCTOR"
16: prt "4  TRANS LINE"
17: prt "5  SHORTED STUB"
18: prt "6  OPEN STUB"
19: prt "7  OP-AMP"
20: prt "8  NPN TRANS"
21: prt "9  FET"
22: prt "10 STOP"
23: prt "11 ANALYZE"
24: prt " "
25: prt " "
26: 0→r6;ent "SELECT FROM LIST→→→→→→→→→→→→→",r6;prt " "
27: if r6=1;prt "(1) RES";gto "res"
28: if r6=2;prt "(2) CAP";gto "cap"
29: if r6=3;prt "(3) IND";gto "ind"
30: if r6=4;prt "(4) T-LINE";gto "t.line"
31: if r6=5;prt "(5) S-STUB";gto "s.stub"
32: if r6=6;prt "(6) O-STUB";gto "o.stub"
33: if r6=7;prt "(7) OP-AMP";gto "op.amp"
34: if r6=8;prt "(8) NPN";gto "npn"
35: if r6=9;prt "(9) FET";gto "fet"
36: if r6=10;prt "(10) PGM FINISH";stp
37: if r6=11;prt "(11) ANALYSIS";gto "anal"
38: gto 26
39: "t.line":1→T[X];enp "SHIELD-IN",M[X]
40: enp "CENTER-IN",I[X],"CENTER-OUT",O[X]
41: enp "SHIELD-OUT",N[X];gto 44
42: enp "NODE A",M[X]
43: enp "NODE B",N[X]
44: enp "Zo",Z[X]
45: enp "QUARTER WAVE FREQ(Hz)?",L[X]
46: if I[X]>N;I[X]→N
47: if M[X]>N;M[X]→N
48: if N[X]>N;N[X]→N
49: if O[X]>N;O[X]→N
50: X+1→X;0→T[X]
51: gto 26
52: "s.stub":3→T[X]
53: gto 42
54: "o.stub":2→T[X]
55: gto 42
56: "res":enp "NODE A",I,"NODE B",J,"RES(OHMS)",V
57: 1/V→V
58: gsb "resl"
59: gto 26
60: "ind":enp "NODE A",I,"NODE B",J,"IND(Hy)",V
61: 1/V→V
62: gsb "indl"
63: gto 26
64: "cap":enp "NODE A",I,"NODE B",J,"CAP(FARADS)",V
65: gsb "capl"
66: gto 26
67: "fet":enp "GATE",K,"SOURCE",J,"DRAIN",I,"GAIN(A/V)",V
68: J→L
69: gsb "trans"
70: gto 26
71: "npn":enp "BASE",K,"EMITTER",J,"COLLECTOR",I,"BETA",r5
72: enp "Rbe(OHMS)",V
73: 1/V→V
74: I→L
75: K→I
76: gsb "resl"
77: L→I
78: J→L
79: r5*V→V
80: gsb "trans"
81: gto 26
82: "op.amp":enp "+IN",K,"-IN",L,"-OUT",I
83: enp "+OUT",J,"GAIN(V/V)",r5,"OUTPUT RES(OHMS)",V
84: 1/V→V
85: gsb "resl"
86: r5*V→V
87: gsb "trans"
88: gto 26
89: "anal":enp "INPUT NODE",E,"OUTPUT NODE",F;N-1→N
90: enp "START FREQ-Hz",G,"STOP FREQ(Hz)",H
91: enp "# DATA POINTS",M
92: enp "FREQ SWEEP-LOG=0(LIN=1)",r6
93: (H-G)/(M-1)→D
94: 10^(log(H/G)/(M-1))→r4
95: G→r0;0→r9;fxd 4
96: r9+1→r9
97: 2*π*r0→W;rad
98: E→O;F→Z
99: gsb "t.load"
100: gsb "det"
101: r5→V;Z→U
102: if (E+F)/2=int((E+F)/2);gto 104
103: U-180→U
104: E→O;E→Z
105: gsb "det"
106: U-Z→U
107: if V=0;-9999→r7;gto 110
108: if r5=0;9999→r7;gto 110
109: V/r5→V;20*log(V)→r7
110: if U>180;U-360→U
111: if U<-180;U+360→U
112: prt "FREQ",r0;prt "AMPL",V;prt "20LOG",r7
113: prt "PHASE",U;prt " "
114: if r6=0;r0*r4→r0
115: if r6#0;r0+D→r0
116: if r9#M;gto 96
117: N+1→N
118: gto 26
119: "indl":R[I,I]+V→R[I,I]
120: R[J,J]+V→R[J,J]
121: R[I,J]-V→R[I,J]
122: R[J,I]-V→R[J,I]
123: if I>N;I→N
124: if J>N;J→N
125: ret
126: "resl":P[I,I]+V→P[I,I]
127: P[J,J]+V→P[J,J]
128: P[I,J]-V→P[I,J]
129: P[J,I]-V→P[J,I]
130: gto 123
131: "capl":Q[I,I]+V→Q[I,I]
132: Q[J,J]+V→Q[J,J]
133: Q[I,J]-V→Q[I,J]
134: Q[J,I]-V→Q[J,I]
135: gto 123
136: "trans":P[I,K]+V→P[I,K]
137: P[J,L]+V→P[J,L]
138: P[J,K]-V→P[J,K]
139: P[I,L]-V→P[I,L]
140: if K>N;K→N
141: if L>N;L→N
```

Without sacrificing speed, an easy-to-use program for a desktop computer lets you take full advantage of circuit-analysis techniques without the problems associated with large-scale time-shared computers.

Getting the program started

After loading the program, you start the analysis by pressing the 9825's Run key; the printer then displays a command list (**Fig 2a**). The first nine entries catalog the types of elements that the program accommodates; items 10 and 11 are Stop and Analyze commands.

To illustrate program syntax and internal software functions, consider a simple RLC analysis problem (**Fig 3a**). As a first step in this analysis, you must start at 1 and consecutively number each node in the network, ensuring that at least one element connects to each node.

Although the program interprets the highest node number as network common, you can assign any numbers you want to the input and output nodes. However, network excitation (an ideal voltage source of

```
142: gto 123
143: "comp":if N>1;gto 146
144: A[1,1]→O;B[1,1]→Z
145: ret
146: 1→O
147: 0→Z
148: 1→K
149: K→L
150: abs(A[K,K])+abs(B[K,K])→S
151: K-1→I
152: I+1→I
153: abs(A[I,K])+abs(B[I,K])→T
154: if S>=T;gto 156
155: I→L;T→S
156: if I#N;gto 152
157: if L=K;gto 163
158: 0→J
159: J+1→J
160: -A[K,J]→S;A[L,J]→A[K,J];S→A[L,J]
161: -B[K,J]→A;B[L,J]→B[K,J];A→B[L,J]
162: if J#N;gto 159
163: K+1→L;L-1→I
164: I+1→I
165: A[K,K]*A[K,K]+B[K,K]*B[K,K]→A
166: (A[I,K]*A[K,K]+B[I,K]*B[K,K])/A→S
167: (A[K,K]*B[I,K]-A[I,K]*B[K,K])/A→B[I,K]
168: S→A[I,K]
169: if I#N;gto 164
170: K-1→C
171: if C=0;gto 179
172: L-1→J
173: J+1→J;0→I
174: I+1→I
175: A[K,J]-A[K,I]*A[I,J]+B[K,I]*B[I,J]→A[K,J]
176: B[K,J]-B[K,I]*A[I,J]-A[K,I]*B[I,J]→B[K,J]
177: it C#I;gto 174
178: if J#N;gto 173
179: K→C
180: K+1→K;K-1→I
181: I+1→I;0→J
182: J+1→J
183: A[I,K]-A[I,J]*A[J,K]+B[I,J]*B[J,K]→A[I,K
184: B[I,K]-B[I,J]*A[J,K]-A[I,J]*B[J,K]→B[I,K
185: if J#C;gto 182
186: if I#N;gto 181
187: if K#N;gto 149
188: 1→L
189: int(N/2)→C
190: if N=2*C;gto 193
191: 0→L
192: A[N,N]→O;B[N,N]→Z
193: 0→I
194: I+1→I
195: N-I+L→J
196: A[I,I]*A[J,J]-B[I,I]*B[J,J]→S
197: A[I,I]*B[J,J]+A[J,J]*B[I,I]→A
198: O*S-Z*A→T
199: Z*S+O*A→Z
200: T→O
201: if I#C;gto 194
202: ret
203: "det":N→r5
204: N-1→N
205: 0→I
206: 0→K
207: K+1→K
208: if K#O;gto 210
209: 1→I
210: 0→J;0→L
211: L+1→L
212: if L#Z;gto 214
213: 1→J
214: P[K+I,L+J]→A[K,L]
215: W*Q[K+I,L+J]-R[K+I,L+J]/W+S[K+I,L+J]→B[K,L]
216: if L#N;gto 211
217: if K#N;gto 207
218: gsb "comp"
219: r5→N
220: √(O*O+Z*Z)→r5
221: Z→Y
222: if O=0;gto 228
223: 180/π*atn(Z/O)→Z
224: if O>0;ret
225: Z+sgn(Y)*180→Z
226: if Y=0;180→Z
227: ret
228: 90*sgn(Y)→Z
229: ret
230: "t.load":if T[1]=0;ret
231: 0→X
232: 0→r1
233: r1+1→r1;0→r2
234: r2+1→r2
235: 0→S[r1,r2]
236: if r2#N+1;gto 234
237: if r1#N+1;gto 233
238: X+1→X
239: if X>20;ret
240: if T[X]=0;ret
241: if T[X]=1;gto 247
242: if T[X]=2;gto 266
243: -1/(Z[X]*tan(.25*W/L[X]))→r1
244: M[X]→Q;N[X]→R
245: gsb 270
246: gto 238
247: -1/(Z[X]*tan(.25*W/L[X]))→r1
248: M[X]→Q;I[X]→R
249: gsb 270
250: N[X]→Q;O[X]→R;gsb 270
251: 1/(Z[X]*sin(.25*W/L[X]))→r1
252: I[X]→P
253: N[X]→R
254: S[R,P]-r1→S[R,P]
255: S[P,R]-r1→S[P,R]
256: O[X]→R
257: S[R,P]+r1→S[R,P]
258: S[P,R]+r1→S[P,R]
259: M[X]→P
260: S[R,P]-r1→S[R,P]
261: S[P,R]-r1→S[P,R]
262: N[X]→R
263: S[R,P]+r1→S[R,P]
264: S[P,R]+r1→S[P,R]
265: gto 238
266: 1/(Z[X]*tan(.25*W/L[X]))→r2
267: 1/(Z[X]*sin(.25*W/L[X]))→r3
268: r3*r3/r2-r2→r1
269: gto 244
270: S[Q,Q]+r1→S[Q,Q]
271: S[R,R]+r1→S[R,R]
272: S[Q,R]-r1→S[Q,R]
273: S[R,Q]-r1→S[R,Q]
274: ret
*399
```

Fig 1—High transportability *characterizes this network-analysis program. The BASIC-like HPL language in which it's written easily translates for use on computers other than the HP 9825.*

Program places no restrictions on input/output-node numbering

unit magnitude) is always between input and common, and output readings are presented in relation to the common terminal. Order of network-element entry is not critical because the analysis doesn't start until you select item 11 on the command list.

To initiate program data entry for this example, enter a number from the command list and press the Continue key. (This key provides the same function as Carriage Return on a larger system, reactivating the computer at the end of data entry.) The program prints the selected network element and then branches to one of the subroutines shown in the command-list flow diagram **(Fig 2b)**.

As the program accesses each subroutine **(Fig 3b)**, it places each element value and related topology information into the appropriate P (resistive), Q (capacitive) or R (inductive) matrix and prints a permanent record of both the questions and the data. It continues this data-collection process until it has entered data describing the complete network. **Fig 3c** represents the final state of the P, Q and R matrices,

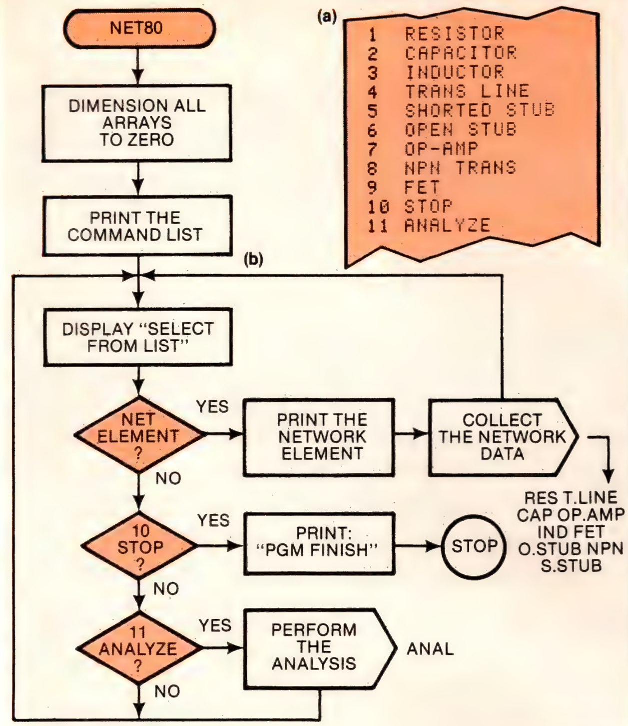
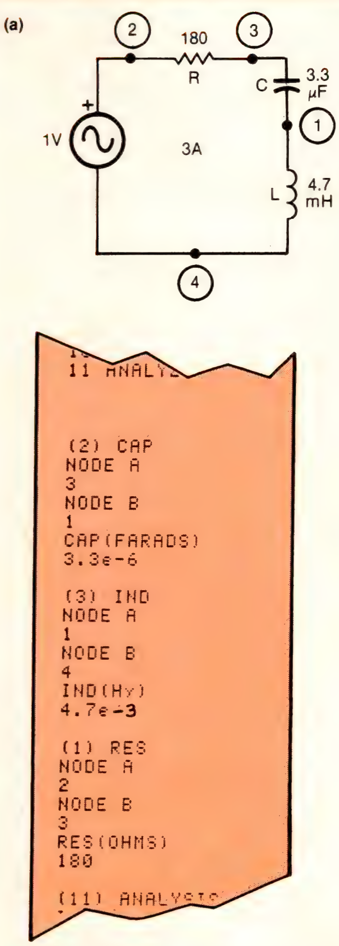
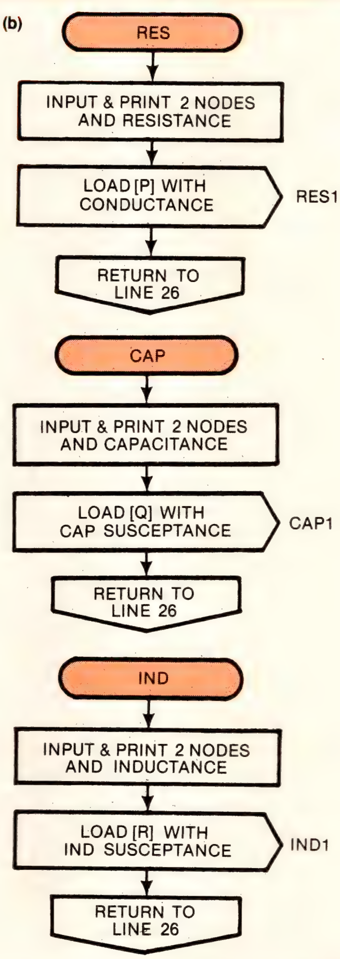


Fig 2—The program *accommodates a wide variety of network elements* **(a)**. *A flowchart* **(b)** *illustrates the element-value collection sequence.*





(c)

P MATRIX (REAL)

0	0	0	0	1
0	$\frac{1}{R}$	$\frac{-1}{R}$	0	2
0	$\frac{-1}{R}$	$\frac{1}{R}$	0	3
0	0	0	0	4

Q MATRIX (CAPACITIVE)

C	0	−C	0	1
0	0	0	0	2
−C	0	C	0	3
0	0	0	0	4

R MATRIX (INDUCTIVE)

$\frac{1}{L}$	0	0	$\frac{-1}{L}$	1
0	0	0	0	2
0	0	0	0	3
$\frac{-1}{L}$	0	0	$\frac{1}{L}$	4
1	2	3	4	

Fig 3—To analyze a simple RLC network (a), *the program uses similar subroutines* **(b)** *to add the resistive, capacitive and inductive components to their respective matrices* **(c)**.

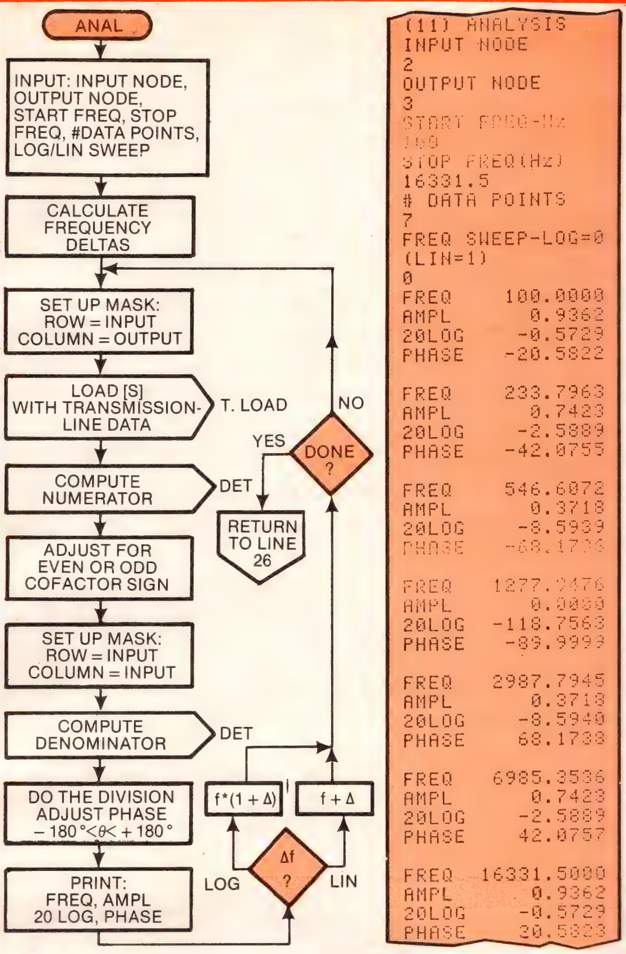


Fig 4—Magnitude and phase calculations *at each new frequency occur in the main analysis loop. The 20log value adds dynamic range to the program.*

respectively, for this example.

Justifying matrix construction

Note that data for each passive element appears, in a perfectly symmetric manner, at the corners of a square in the appropriate matrix. Furthermore, this data is centered on a diagonal, with the node numbers defining both row and column position. To show why this appearance results, write the current equations in terms of the node voltages. For nodes 1 through 4,

$$sC(V_1 - V_3) + \left(\frac{1}{sL}\right)(V_1 - V_4) = 0$$

$$\left(\frac{1}{R}\right)(V_2 - V_3) = I_2$$

$$\left(\frac{1}{R}\right)(V_3 - V_2) + sC(V_3 - V_1) = 0$$

$$\left(\frac{1}{sL}\right)(V_4 - V_1) = -I_2.$$

Collecting the terms by the various node voltages gives all of the coefficients for each respective nodal expression the dimensions of admittance:

$$\left(sC + \frac{1}{sL}\right)V_1 + (0)V_2 + (-sC)V_3 + \left(-\frac{1}{sL}\right)V_4 = 0$$

$$(0)V_1 + \left(\frac{1}{R}\right)V_2 + \left(-\frac{1}{R}\right)V_3 + (0)V_4 = I_2$$

$$(-sC)V_1 + \left(-\frac{1}{R}\right)V_2 + \left(sC + \frac{1}{R}\right)V_3 + (0)V_4 = 0$$

$$\left(-\frac{1}{sL}\right)V_1 + (0)V_2 + (0)V_3 + \left(\frac{1}{sL}\right)V_4 = -I_2.$$

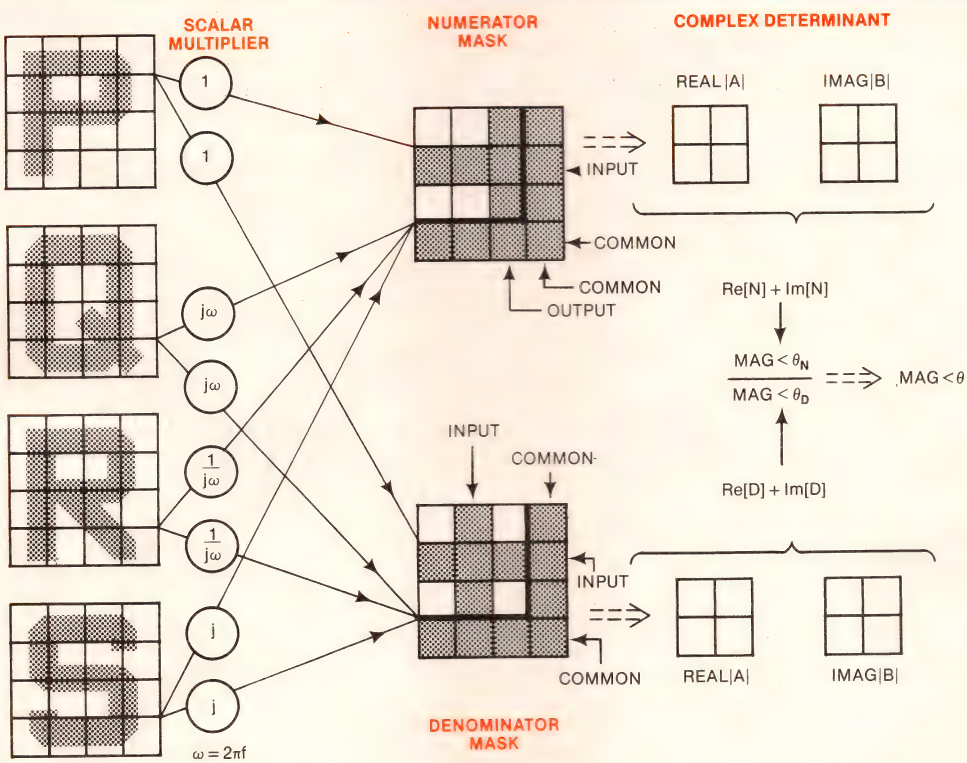


Fig 5—The RLC network's input, output and common nodes *define the masks used to create the real and imaginary parts of the complex determinants for the numerator and denominator. The quotient of the complex vectors prints as a magnitude and phase.*

Active-device modeling approach parallels that for passive units

Then, separating these coefficients into resistive, capacitive and inductive components shows that the complex-frequency terms containing s and 1/s represent the only difference between those components and the P, Q and R matrices. But these frequency terms factor out because they are scalar multipliers in both the Q and R matrices.

Getting down to cases

With this justification of the program's data-entry-phase operation, you're ready to begin the network analysis. Enter 11 from the command list. After collecting input and output node numbers, start and stop frequencies and the number of data points for the frequency sweep (including starting frequency), the HP 9825 runs through the program and provides a printout. This data is actually the quotient of two values returned from the DET subroutine **(Fig 4).**

At every frequency, each element of the P matrix passes through its corresponding position in the numerator-blockout mask to form the real part of the matrix's complex determinant **(Fig 5).** With appropriate frequency adjustments, the Q, R and S matrices receive similar treatment for summing into the determinant's imaginary part. After similar treatment of the denominator, the program then evaluates the determinants and converts the information into polar coordinates to present as final output data.

The numerator mask suppresses the rows representing the input and common nodes and the columns representing the output and common nodes. Suppression of rows and columns representing the input and common nodes occurs in the denominator mask. **Fig 6** illustrates the details of this function, and **Ref 2** offers the underlying theory and a treatment of the analysis method.

When the computer finishes printing the frequency-analysis data, the program returns to the command-list entry point. If necessary, you can then enter negative passive elements to modify various network values for further analysis.

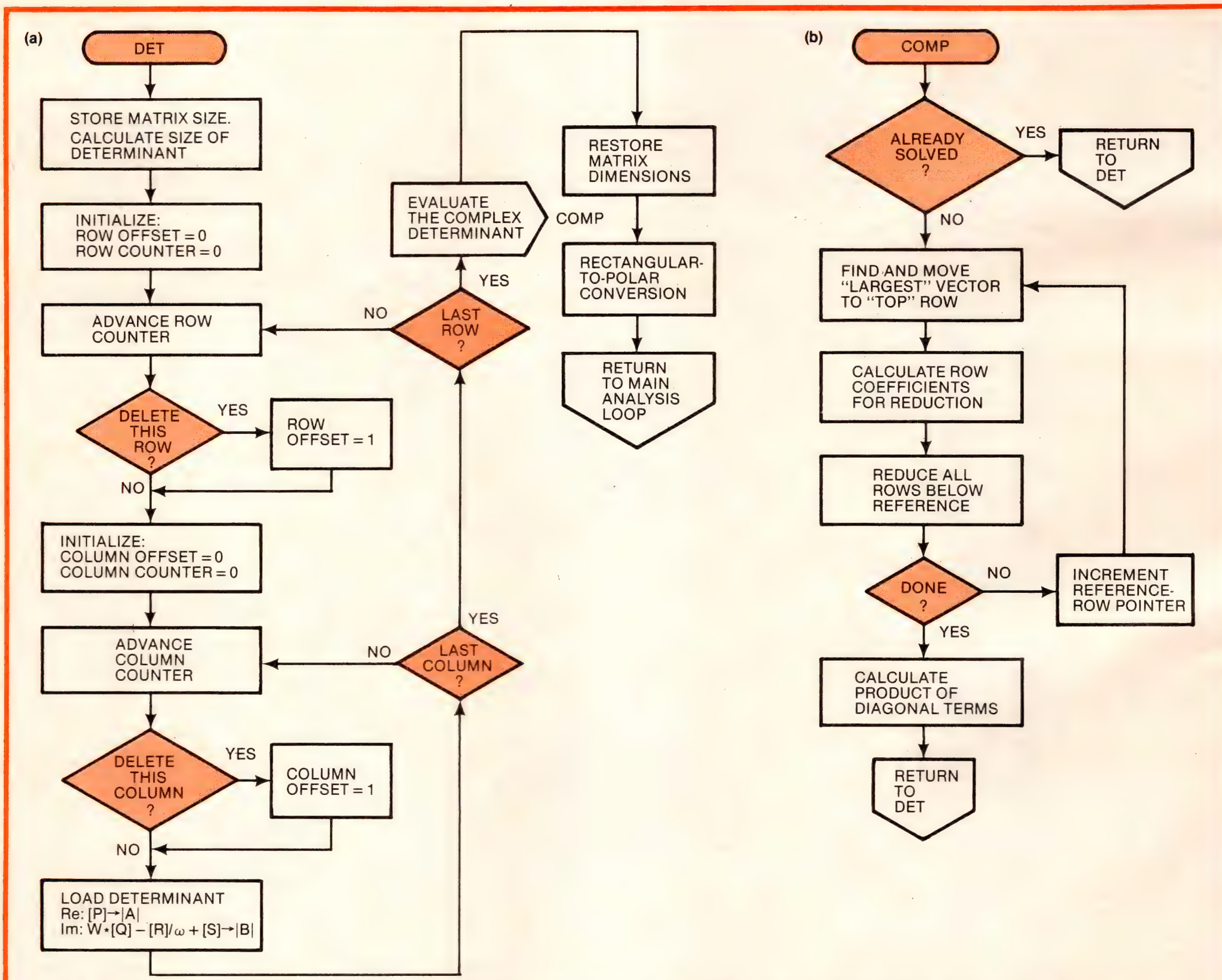


Fig 6—The program creates the complex determinant *by deleting two rows and columns from the indeterminant matrix* ***(a)****. The determinant is upper triangulated, and the product of the diagonal elements returns in Cartesian coordinates* ***(b)****.*

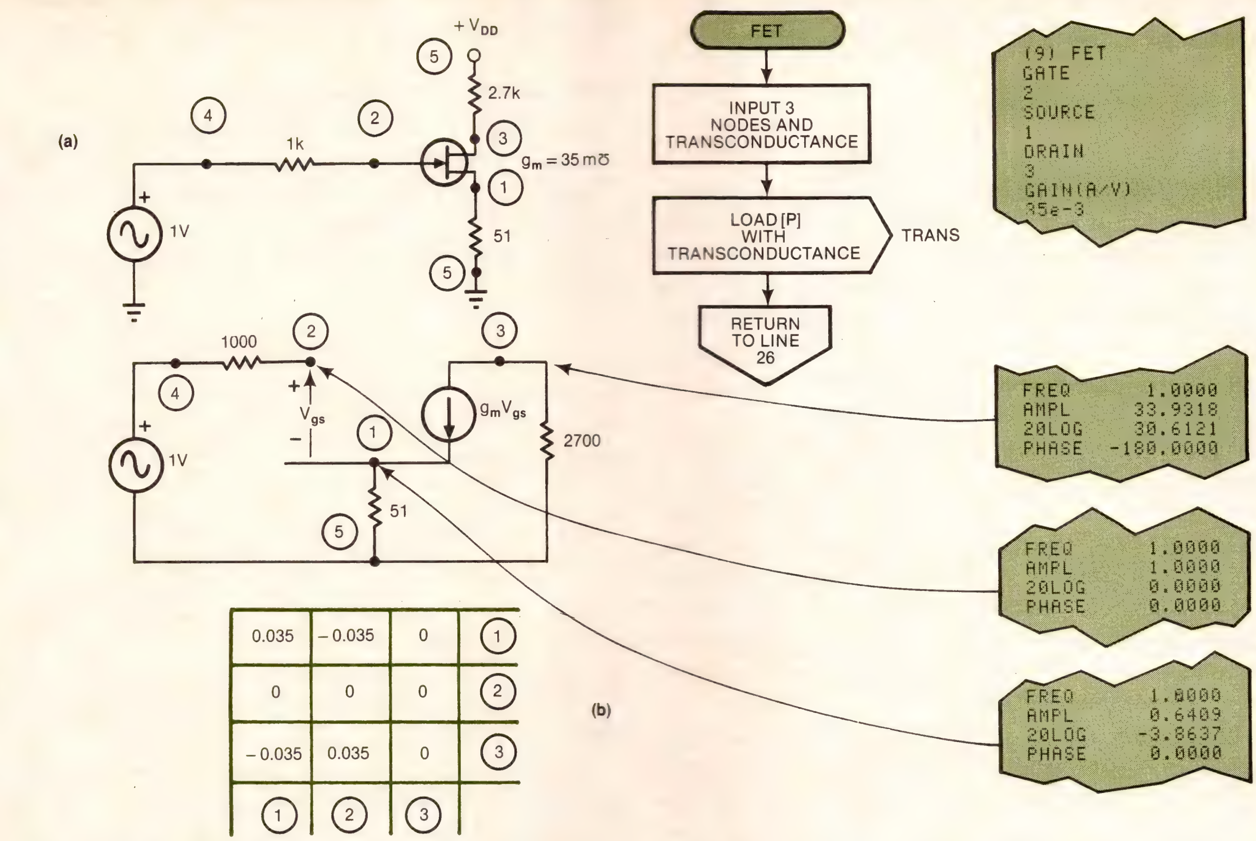


Fig 7—An FET is readily analyzed *in an admittance matrix because its first-order ac model* **(a)** *is a simple transconductance. Although not centered, the FET's transconductance contribution to the P matrix* **(b)** *does appear symmetrically.*

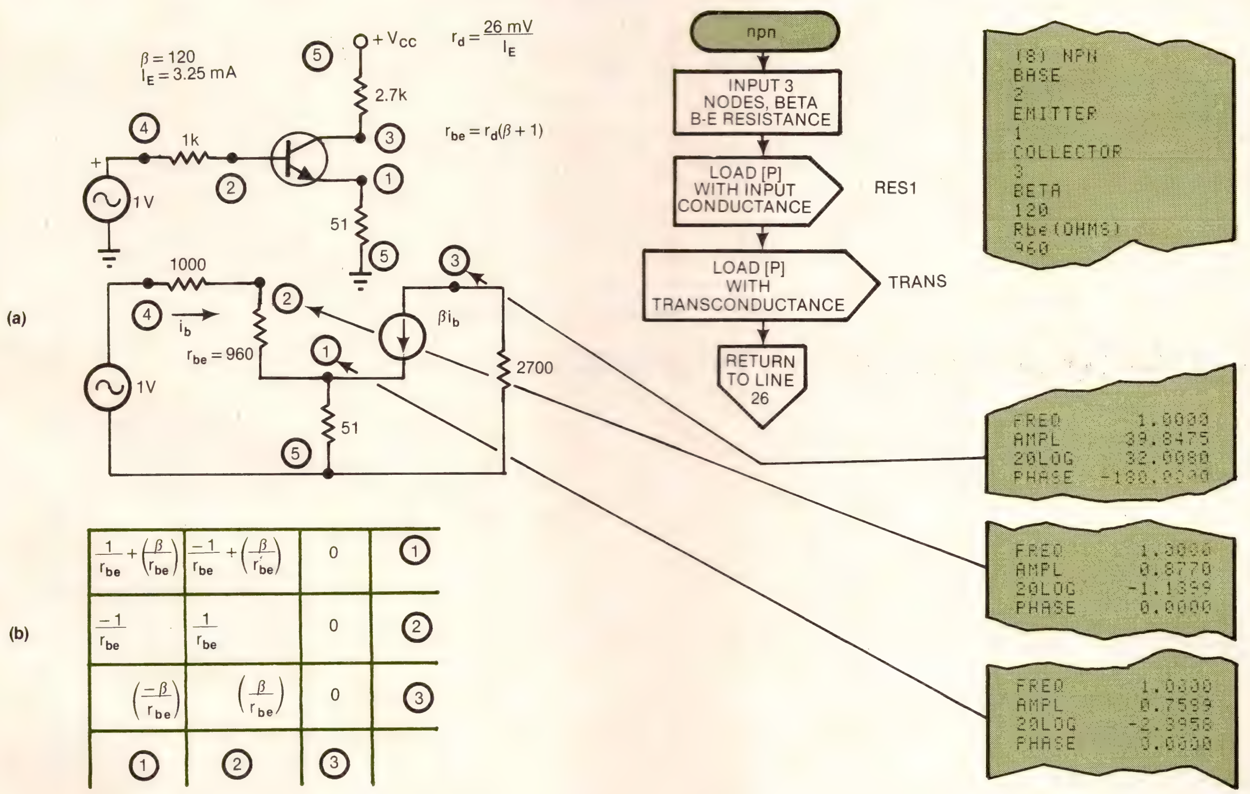


Fig 8—For network analysis, the program models an npn transistor *as a resistance and a transconductance* **(a)**. *It then loads these elements separately into the P matrix* **(b)**.

Z-mismatched transmission lines appear to contain active devices

Active devices present no problems

The approach to active-device modeling is similar to that for passive devices. Because an FET's first-order ac model is merely a transconductance **(Fig 7)**, this type of active device is the simplest one for analysis in an admittance matrix. Note that interelectrode components (such as capacitance) between existing nodes require no additional memory space—you can handle them as you would any passive component.

You can model any other type of transistor as a simple extension of the FET by calculating the equivalent of its input voltage from the values of input current and base-emitter resistance **(Fig 8)**. For this circuit model, P-matrix loading requires two separate steps: First the program loads the resistive component r_{be}; then it calculates the transconductance (using the transistor's base-emitter resistance and current gain β) and loads that quantity into the P matrix.

Op-amp modeling usually utilizes a differential-voltage-gain block with a defined output impedance **(Fig 9)**. With the same subroutines used for the transistor, the program calculates the block's low-frequency Norton output equivalent and loads it into the P matrix as a resistance and transconductance.

What about transmission lines?

The program also accommodates transmission-line analysis, but this type of passive network element presents an interesting problem—you must model it as an active device **(Fig 10)**.

A transmission-line analysis starts with this equation **(Ref 3)**:

$$E_1 = E_2 \cosh \gamma x + I_2 Z_O \sinh \gamma x.$$

Limiting the model to lossless lines and assuming implied line reciprocity, applying hyperbolic-to-circular identities yields

$$I_1 = \left(\frac{-j}{Z_O \tan \theta}\right)E_1 + \left(\frac{j}{Z_O \sin \theta}\right)E_2$$

$$I_2 = \left(\frac{-j}{Z_O \tan \theta}\right)E_2 + \left(\frac{j}{Z_O \sin \theta}\right)E_1.$$

In each of these equations, the first and second voltage coefficients are admittance and transadmittance components, respectively.

A significant difference exists between this transmission-line model and the models cited earlier—you can no longer factor the complex frequency term out of the

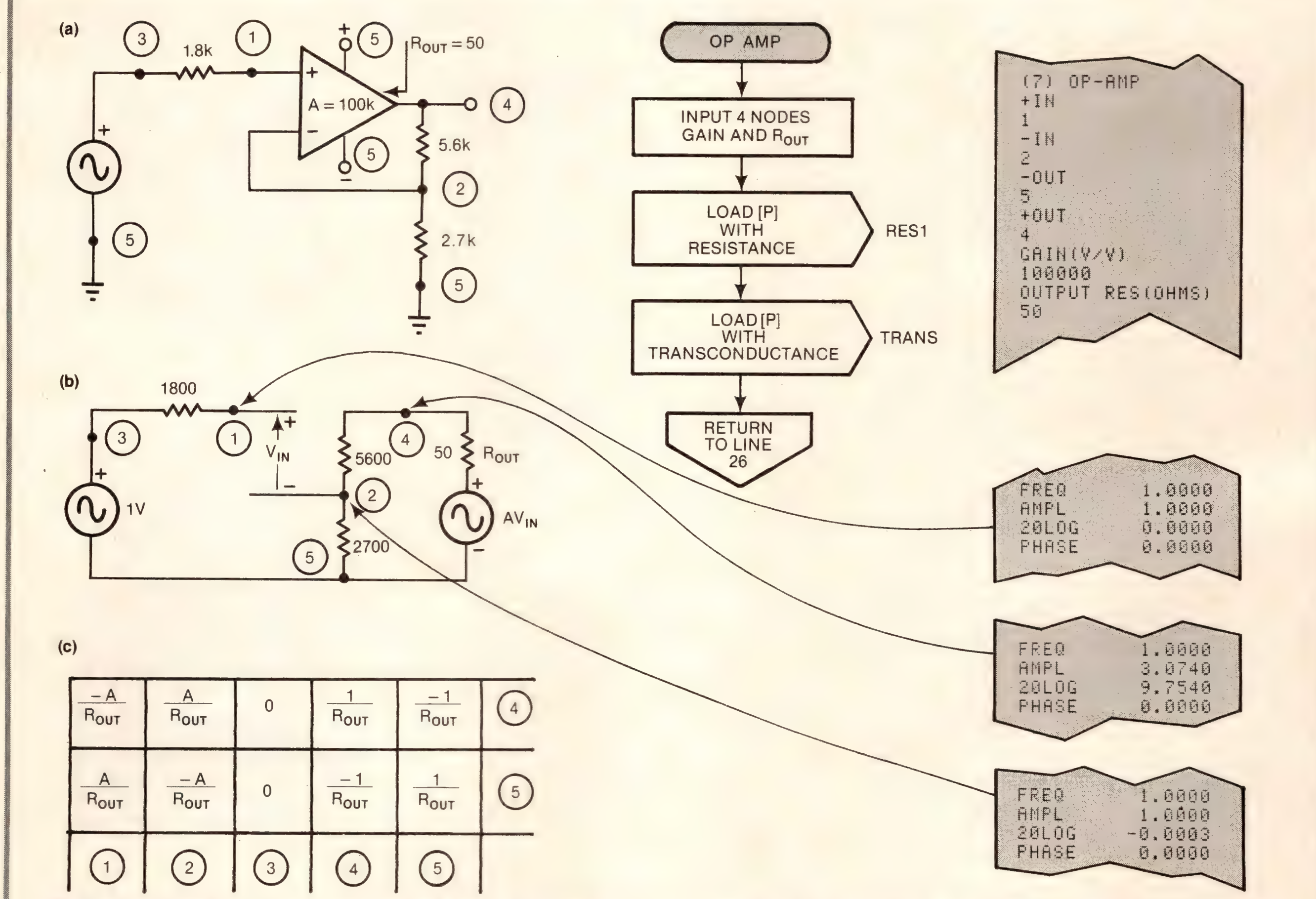
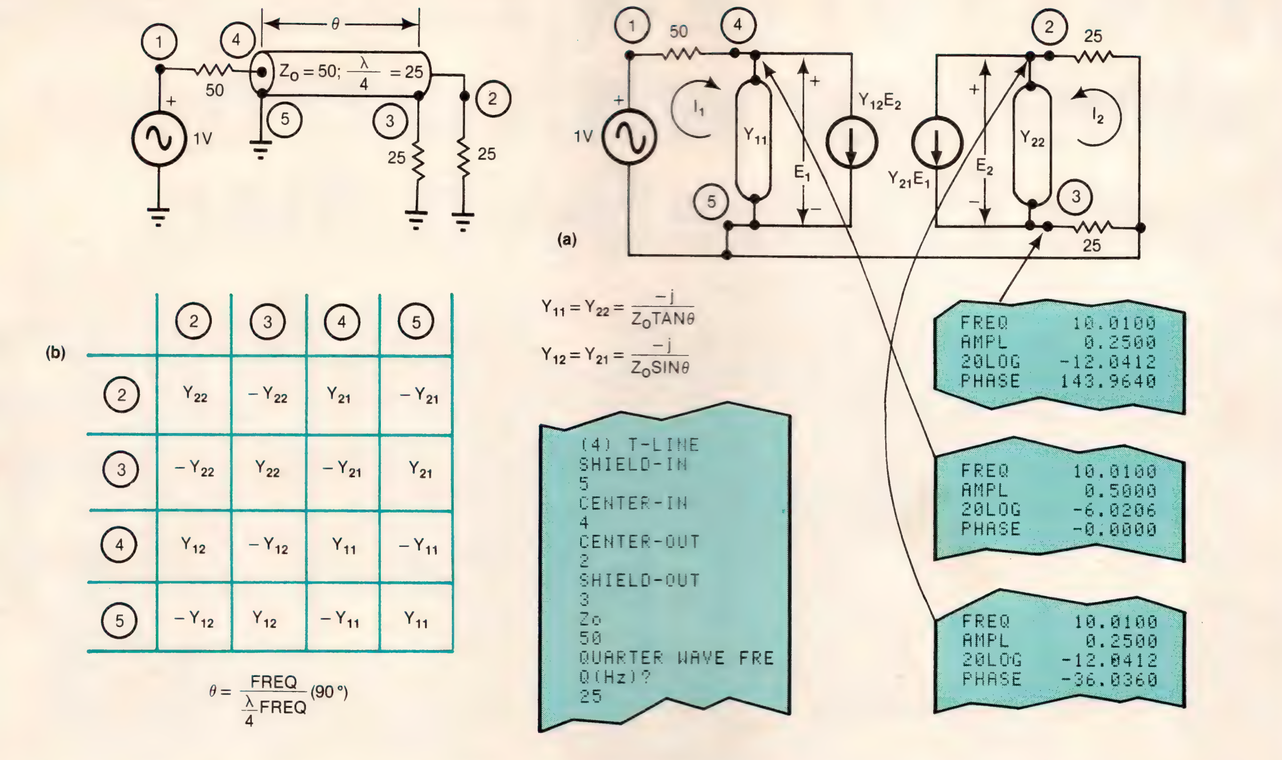


Fig 9—Two-port modeling *is illustrated by this noninverting-op-amp circuit* ***(a)****. The program calculates the circuit's low-frequency Norton equivalent* ***(b)*** *and loads it into the matrix* ***(c)*** *as a resistance and transconductance.*



	2	3	4	5
2	Y_{22}	$-Y_{22}$	Y_{21}	$-Y_{21}$
3	$-Y_{22}$	Y_{22}	$-Y_{21}$	Y_{21}
4	Y_{12}	$-Y_{12}$	Y_{11}	$-Y_{11}$
5	$-Y_{12}$	Y_{12}	$-Y_{11}$	Y_{11}

Fig 10—Transmission lines appear to contain active devices *at generator and load* ***(a)****. S-matrix loading* ***(b)*** *occurs at each new frequency because the admittance parameters are trigonometric functions of frequency.*

matrix. Thus, you'll now require an additional n×n matrix and a network list for lines. Execution time also increases, because the program now must load the new matrix at each new frequency. However, an IF statement does save execution time when the transmission-line list is empty by bypassing transmission-line-subprogram operations.

You can derive the line's open- and short-circuit stubs by opening ($I_2=0$) or shorting ($E_2=0$) the transmission-line model's output end and solving for the input admittance. Both exercises yield a circular-function 2-terminal admittance for loading into the S matrix like transmission-line data at each new frequency. To minimize memory requirements, these elements use a subset of the data-acquisition- and transmission-line-matrix loader routines. **EDN**

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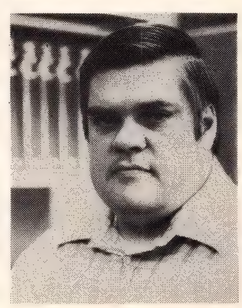
Author's biography



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Article Interest Quotient (Circle One)
High **482** ***Medium*** **483** ***Low*** **484**

Low-cost instrument measures 4-decade power

Using standard parts, a watt/watt-hour meter calculates power consumption for line-powered devices over an extremely wide measurement range—2W to 2 kW FS. And its multiple analog and digital outputs allow both direct and time-related power readings.

Jim Williams, National Semiconductor Corp

If you must monitor the usage of costly electricity in commercial, industrial or consumer equipment designs, build the inexpensive but versatile watt/watt-hour meter described in this article. It resolves power measurements to as low as 0.1W, achieving 2% accuracy over 25±5°C. And it can determine the power consumption of any 115V ac unit, from large factory machines to small hand-held tools. The instrument requires only about $175 worth of off-the-shelf parts, whereas many conventional power meters cost much more and provide lower performance.

To handle a wide variety of power measurements, mostly in cases where energy conservation has high priority, the instrument provides three analog and two digital power-related outputs. One analog output—serving a 200-μA FS meter—displays power values in watts. Another furnishes 0 to 5V for driving strip-chart recorders, while the third supplies instantaneous-power-output levels for use in external-tracking applications. One of the digital outputs—a readout—indicates time-based or watt-hour readings; the second supplies watt-hour data for use by external equipment.

A look at the overall approach

The watt/watt-hour meter's design is straightforward (**Fig 1**). The device under measurement plugs into a standard 115V ac outlet mounted on the instrument's front panel. With line power applied, the ac voltage across the monitored load passes through a resistor divider and feeds (via an op amp) to an analog

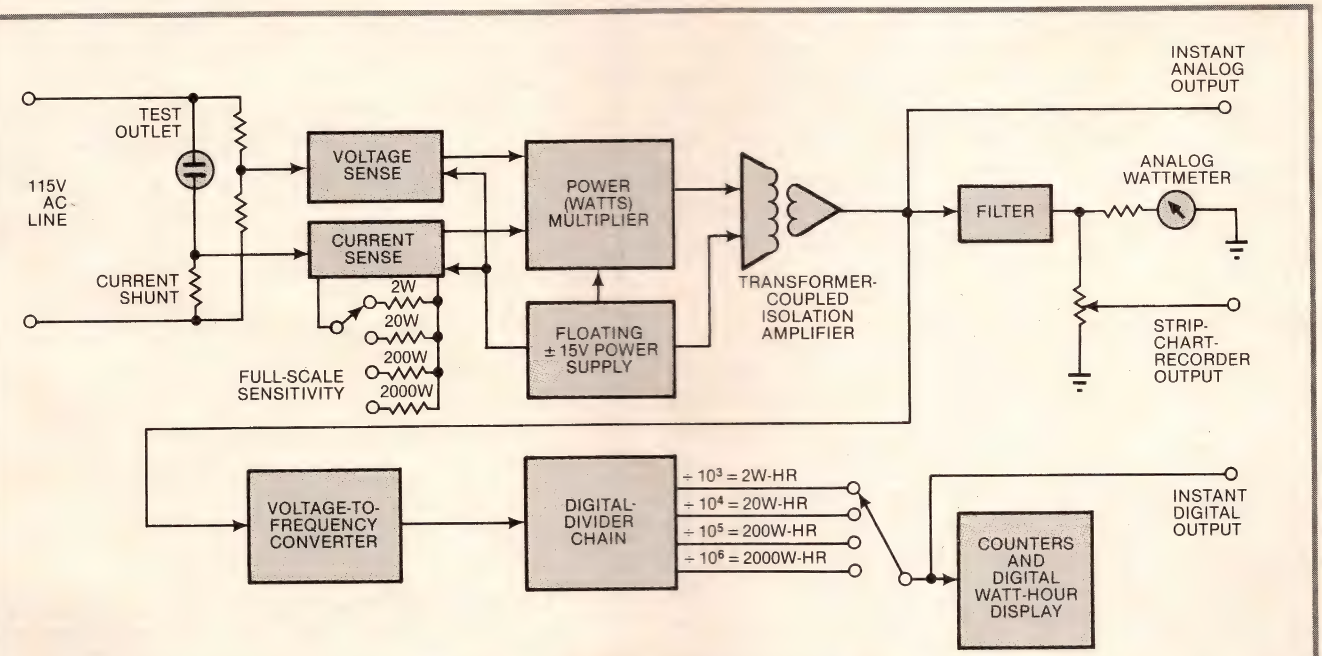


Fig 1—An inexpensive watt/watt-hour meter *incorporates (in series) a current shunt, voltage- and current-sense amplifiers, a power multiplier and a transformer-coupled isolation amplifier. These circuits generate amplitude-modulated pulses that represent the monitored device's instantaneous power consumption, measured in watts. Voltage-to-frequency conversion precedes a counter and a digital display of power levels in watt-hours.*

Single low-resistance shunt handles all four power ranges

power multiplier.

The voltage across a low-resistance shunt represents the current through the load. Even when measuring a 20A max flow, this shunt needs only 133 mV—a feature that eliminates high-resistance-current-shunt inaccuracies. Additionally, by accommodating all four power ranges—2, 20, 200 and 2000W FS—the single shunt eliminates the need to switch-in high-impedance shunts for high-sensitivity scales.

The instrument's measurement technique utilizes the low input error in a current-sense amplifier, whose output also goes to a power multiplier. Switchable gain within the amplifier makes possible the 4-decade sensitivity setting. A 4-quadrant configuration, the power multiplier produces an output representing the test load's true instantaneous-power product (E×I), regardless of the load's relative voltage and current phases.

Because the multiplier and its associated voltage- and current-sense amplifiers connect directly to the ac line, though, they require a floating ±15V power supply. Consequently, you can't safely monitor their outputs with grounded test equipment, such as strip-chart recorders. To deal with this problem, the multiplier's output drives an isolation amplifier that operates at unity gain but has no galvanic connection between its input and output terminals. The amplifier employs pulse-amplitude-modulation techniques in conjunction with a small transformer. By grounding its output, you can safely connect test equipment to all circuits following the transformer.

In addition to driving an analog meter and a strip-chart recorder, the isolation amplifier's output also biases a voltage-to-frequency (V/F) converter, which in turn combines with digital counters to form a digital integrator. This circuit translates the amplifier's analog outputs into time-related power levels. Varying the counters' divide ratio (and thus the power levels) produces the instrument's four watt-hour ranges.

Multiplier portrays instant power

The hardware implementation of this overview appears in **Fig 2**. At the ac-line input, voltage division occurs in the 100- and 4.4-kΩ resistor string. Connected to this string, A_{2A} serves as a buffer amplifier and feeds the voltage-sense input to the power multiplier. Also working off the line input, A_1 monitors the voltage across the current shunt at a fixed gain of 100. Two 1N1195 diodes and two 20A fuses protect A_1 and the current shunt from shorts across the load's test socket. Receiving A_1's output, amplifier A_{2B} provides gain, calibrated wattage switching from 2 to 2000W FS and the power multiplier's current-sense input.

Composed of amplifiers A_{3C} and A_{3D} and an LM394 IC's dual transistors, the multiplier—a variable transconductance type—uses its current-sense input to vary a 2N2222 transistor amplifier's gain. This amplifier receives A_{2A}'s voltage-sense output as its input.

At the multiplier's output, A_{3C} produces an output representing the load's instantaneous power consumption (**Fig 3**, trace A). This output in turn biases a pulse-amplitude-modulating isolation amplifier (A_{3A} and A_{3B}) and three transistors (Q_1 to Q_3).

Generating an oscillator output (trace B), A_{3A} biases the Q_1/Q_2 switch connected across the transformer's primary. Meanwhile, A_{3B}'s negative input measures the pulses' amplitude at the transformer's primary. A_{3B} then servo-controls the pulses to the same amplitude as those received at its positive input (biased by the multiplier's output). Transistor Q_3 provides current-drive capability and completes A_{3B}'s feedback path.

Trace C in **Fig 3** illustrates how Q_3's emitter voltage changes to meet the servo-loop requirements. Trace D shows the pulses applied to the transformer. Note that these pulses' amplitudes form an envelope whose amplitude equals the multiplier's output.

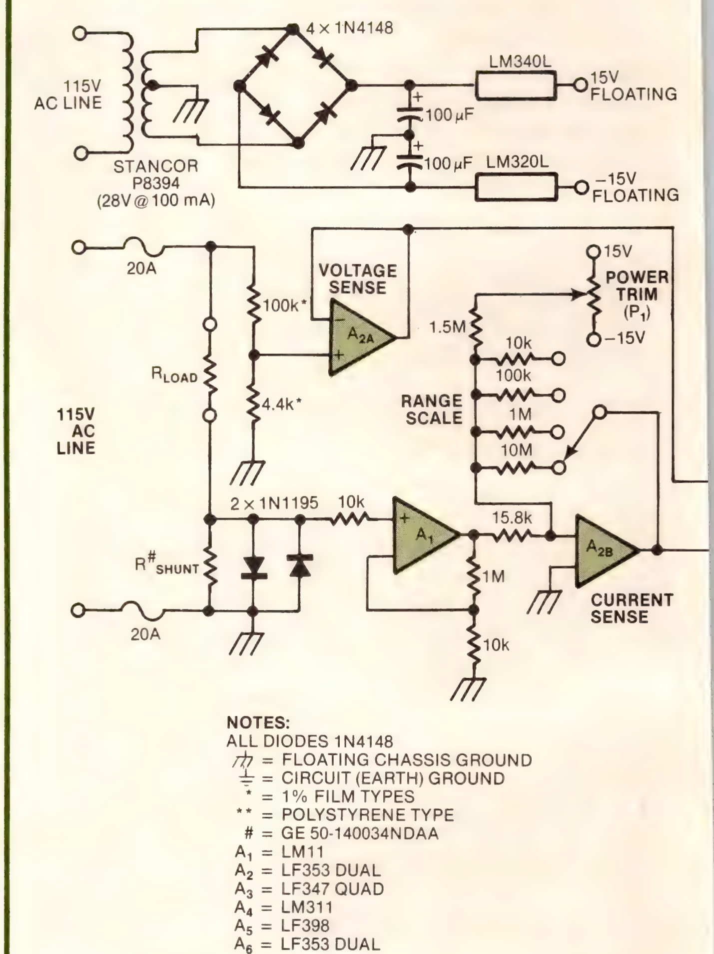


Fig 2—Careful parts selection and skillful circuit design *produce a test instrument that measures the power consumption of any 115V ac-powered device. The instrument provides a 4-decade power-measuring range—2, 20, 200 and 2000W FS—at 2% accuracy and over 25±5°C. Three analog and two digital outputs accommodate a wide variety of internal and external power-measurement applications.*

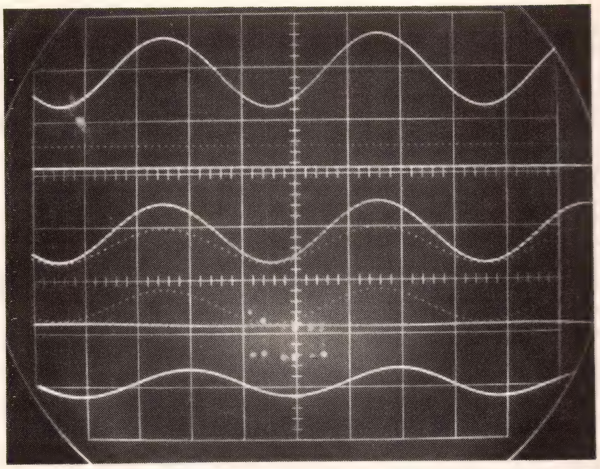
A

B

C

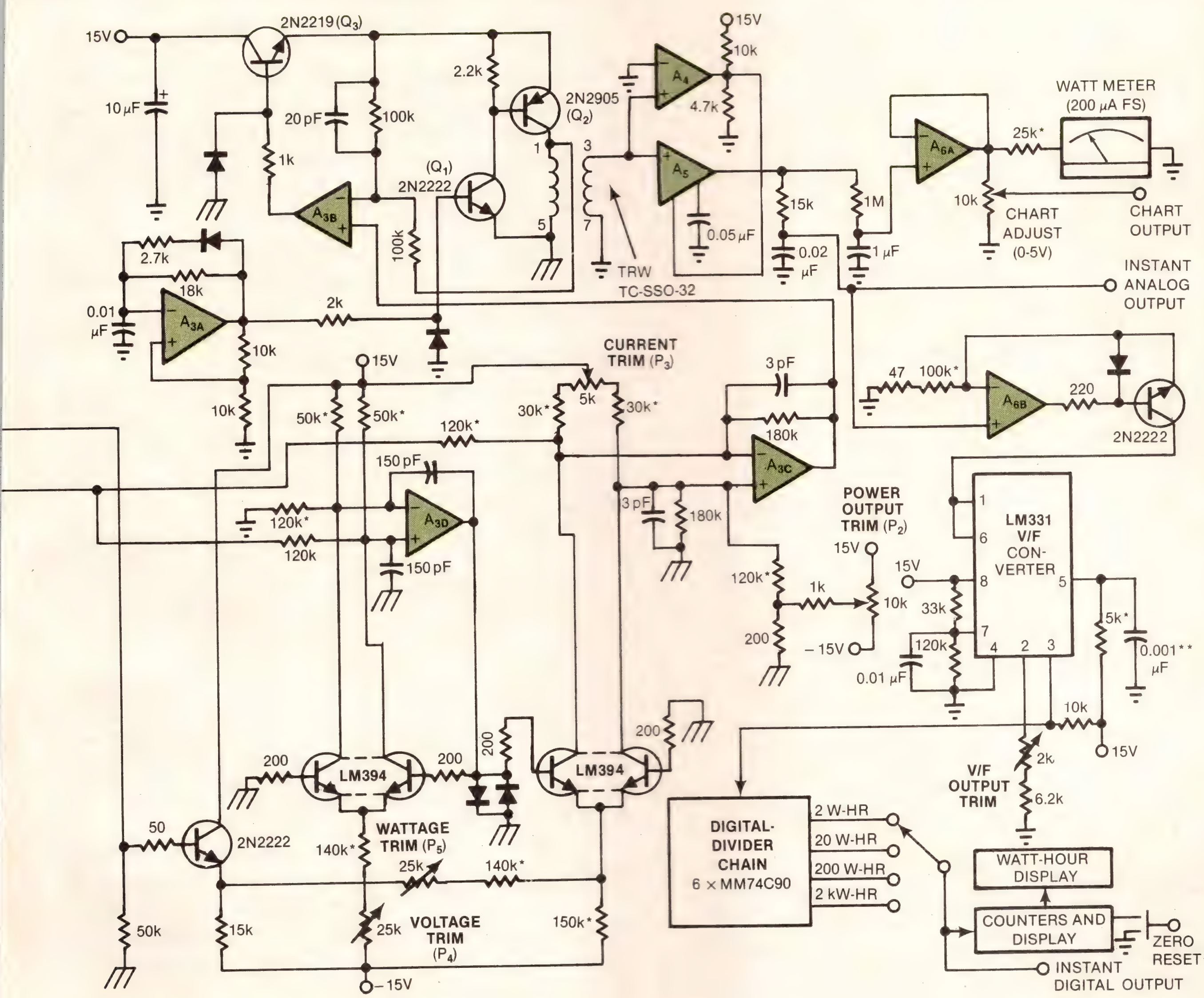
D

E



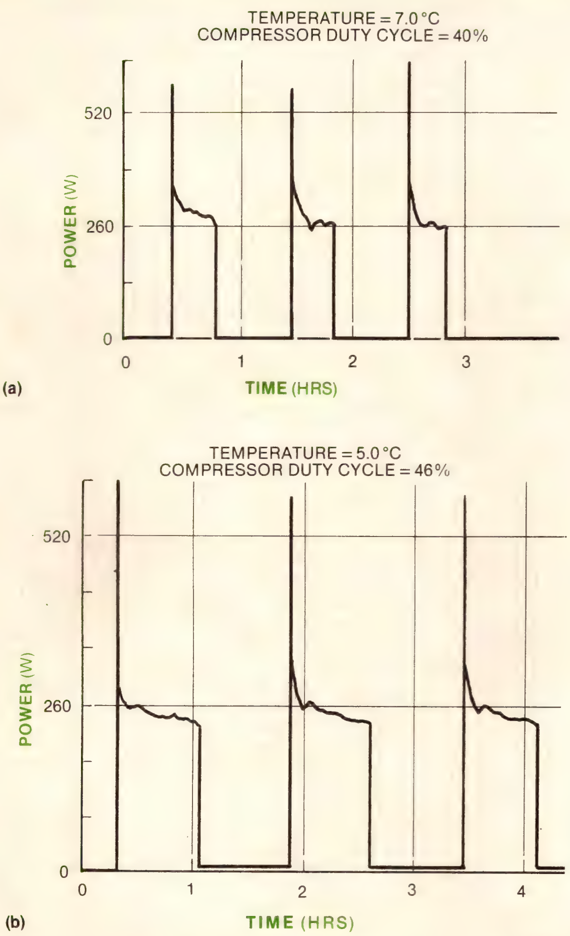
TRACE	VERTICAL	HORIZONTAL
A	5V/DIV	
B	50V/DIV	
C	5V/DIV	2 mSEC/DIV
D	10V/DIV	
E	10V/DIV	

Fig 3—During instrument operation, the power multiplier's output *(trace A) represents the monitored device's instantaneous power consumption. Biased by this output, A_{3A}'s oscillator output (refer to* **Fig 2***) biases the Q_1/Q_2 switch (trace B). Completing the feedback path to A_{3B}, Q_3 changes its emitter voltage to maintain servo-loop needs. Via Q_1, Q_2, Q_3, A_{3A} and A_{3B}, amplitude-modulated pulses arrive at the isolation transformer's primary (trace D). Connected to this transformer's secondary, A_5's output represents a sampled version of the monitored device's power consumption (E).*



Pulse sampling and filtering smooth out power-signal levels

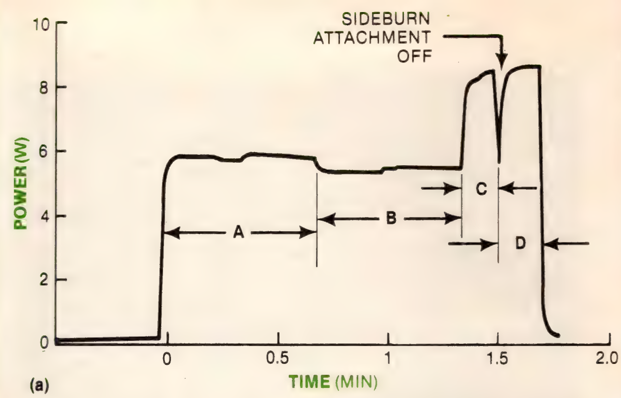
The amplitude-modulated pulses appear at the transformer's secondary, which is referenced to the instrument's earth ground. Each pulse's amplitude gets measured by a sample/hold amplifier (A_5) whenever A_4 generates a Sample command. Lightly filtered by the 15-kΩ, 0.02-μF network, A_5's output provides a sampled version of the load's instantaneous power consumption (trace E). Heavy filtering by the 1-MΩ, 1-μF network's time constant produces a smoother version of the sampled power signal. This signal drives the watts analog-meter and strip-chart-recorder outputs via the A_{6A} buffer.



TEMPERATURE (°C)	POWER CONSUMED (W)	kW-HR PER CYCLE	COST PER DAY	COST PER YEAR
7	260	0.104	\$0.0998	\$36.44
5	260	0.119	\$0.1147	\$41.89

(c)

Fig 4—Connected to the instrument's Chart Output terminal, *a strip-chart recorder logs a refrigerator compressor's power consumption at 260W for several hours. At a 7°C temperature setpoint, the compressor functions at a 40% duty cycle* ***(a)****; lowering the temperature to 5°C increases this duty cycle to 46%* ***(b)****. Extrapolated data* ***(c)*** *shows that the lower temperature results in increased kilowatt-hour consumption per cycle and therefore in higher operating cost.*



FACIAL AREA	POWER CONSUMED (W)	WATT-HOURS	COST PER SHAVE* (CENTS)
CHEEKS (A)	5.8	0.173	0.00692
UPPER & LOWER LIPS (B)	5.4	0.123	0.00492
RIGHT SIDEBURN (C)	8.4	0.063	0.00252
LEFT SIDEBURN (D)	8.4	0.061	0.00244

*BASED ON \$0.04 PER kW-HR

(b)

Fig 5—Monitoring the power consumption *of a small electric razor via a strip-chart recorder, the watt/watt-hour meter generates instantaneous readings over short intervals* ***(a)****. With this accumulated data, you can make detailed power-cost calculations* ***(b)****.*

In conjunction with a digital-divider chain, an LM331 V/F converter forms a digital time integrator. To bias the V/F converter, A_5's lightly filtered output goes to A_{6B}. Driven by the V/F converter's output, the divider chain sets the integrator's time constant and switches the scale factor for watt-hour measurements. Additional counters drive a digital readout that shows the actual measurements. Pressing the Zero Reset pushbutton resets the watt-hour readout.

Use this procedure for calibration

To calibrate the watt/watt-hour meter, shut off the instrument's ac line power and remove the two 20A fuses. Set the Range Scale switch to 2. Then apply power and adjust the Power Trim pot (P_1) so 0.00V appears at A_{2B}'s output.

Turn off the ac line power. Then disconnect the power multiplier's two input lines and connect them to the instrument's floating ground. Turn on line power and adjust the Power Output Trim pot (P_2) for 0.00V at A_{6A}'s output.

Once more, turn off ac line power. Unground the multiplier's current-sense input but leave the voltage-sense input grounded. Then turn on line power and apply a 10V p-p 60-Hz signal to the multiplier's current-sense input lead. Adjust the Current Trim pot (P_3) for 0.00V at A_{6A}'s output.

Now turn off ac line power yet again, ground the multiplier's current-sense input and unground the voltage-sense input. Turn on the power and adjust P_4 (the Voltage Trim pot) for 0.00V at A_{6A}'s output. Then turn off the power and reconnect the multiplier's current-sense input into the circuit.

Next, turn on the line power and read ac line voltage with a precision digital voltmeter. Plug a known load

V/F converter and divider chain form a digital integrator circuit

(eg, a 1% power resistor) into the instrument's test outlet. Adjust the Wattage Trim pot (P_5) until the analog meter reads the correct wattage (watts equals line voltage times load resistance).

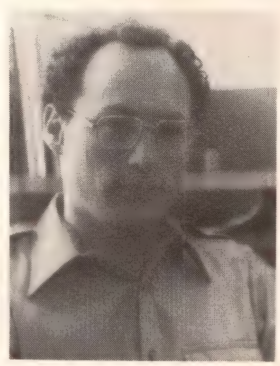
Finally, turn off line power and disconnect A_{6B}'s positive input line. Then turn on the power and apply 5.00V to A_{6B}'s positive line. Adjust the V/F Output Trim pot (P_6) until the LM331's output at pin 3 runs at 27.77 kHz. Then turn off line power and reconnect A_{6B}'s positive input line.

A watt/watt-hour meter calibrated in this manner can accurately measure the power consumption of any 115V ac-powered device, large or small. Connecting the instrument to a home refrigerator demonstrates its prowess with large equipment: In one test, the refrigerator operated for 3½ hrs at a temperature setpoint of 7°C (**Fig 4**), and each time its compressor turned on, it consumed approximately 260W. As the compressor warmed up, power consumption actually decreased slightly. Changing the refrigerator's temperature control to 5°C increased the compressor's duty cycle by 15%. This power change reflects directly in the unit's per-cycle kilowatt-hour consumption.

Connecting the watt/watt-hour meter to an electric razor demonstrates its ability to monitor small equipment. In this setup, the meter recorded the electric razor's power consumption during a face-shaving exercise (**Fig 5**). Note that various facial areas cost more to shave than others.

Time-related power computations revealed that a complete daily shave costs about $0.09 per year. If this is excessive, a user could economize by growing a beard. **EDN**

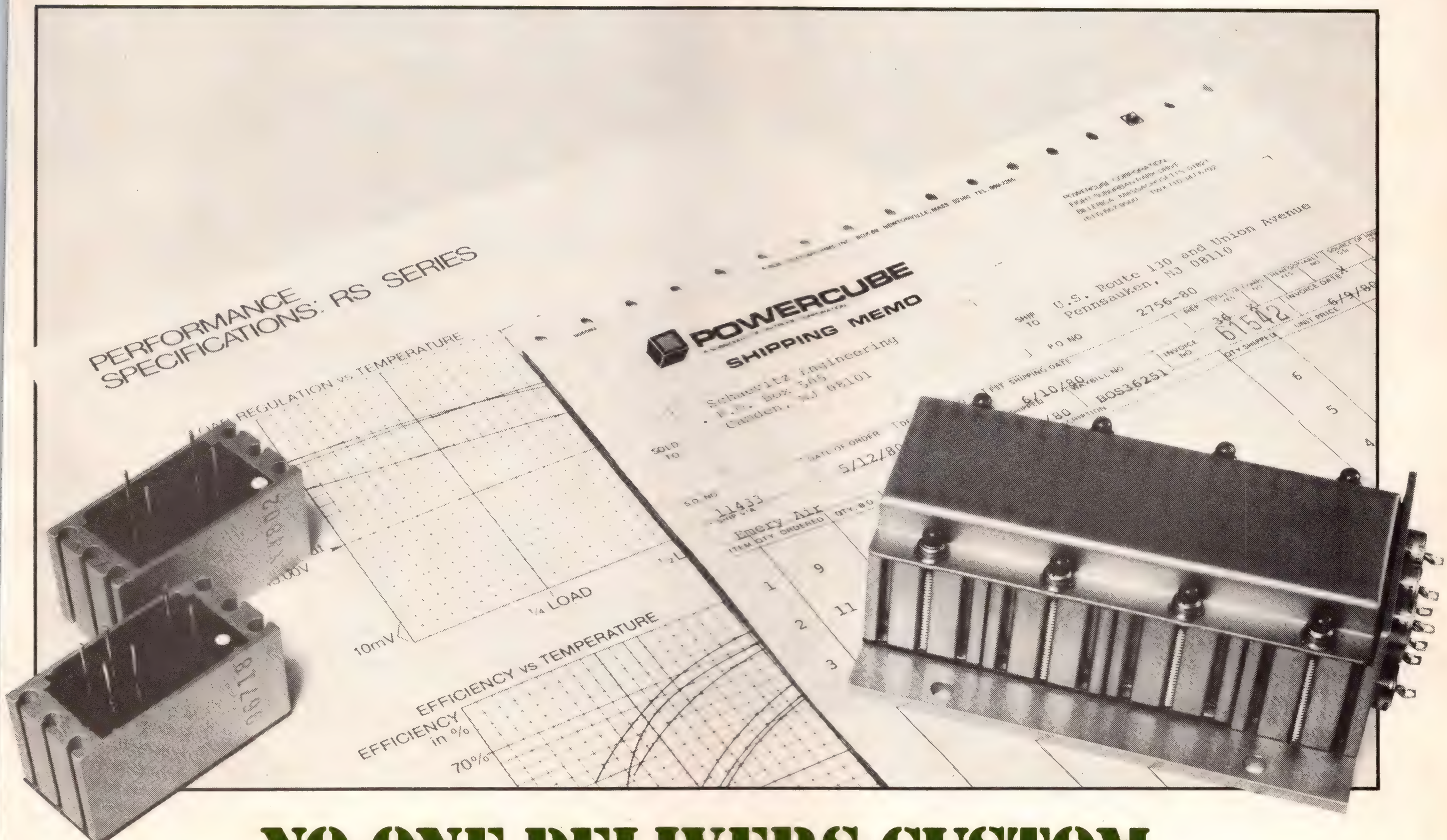
Author's biography



Jim Williams is a design engineer with National Semiconductor Corp's Linear Applications Group, Santa Clara, CA, specializing in analog-circuit and instrumentation development. Previously, he worked as an analog-systems and -circuit consultant at Arthur D Little Inc and directed the Instrumentation Development Lab at the Massachusetts Institute of Technology. Jim studied psychology at Wayne State University and in his spare time enjoys skiing, art and collecting antique scientific instruments.

Article Interest Quotient (Circle One)
High 479 *Medium* 480 *Low* 481

EXEMPLARY PERFORMANCE



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DON'T LET DRIVING YOUR MEMORY DRIVE YOU CRAZY.

Analyze size, maintenance factors to ensure memory reliability

By analyzing the effects of RAM size and error-maintenance techniques, you can determine how to design-in the memory-system reliability you require.

Steven Grossman and **Fred Jones,** Mostek Corp

Utilizing the computerized reliability model described in Part 1 (EDN, January 21, pg 131), this 2-part series concludes by examining graphical presentations of memory-system reliability and the effects of various maintenance schedules. Although the system-reliability model described in these articles doesn't establish a minimum acceptable reliability level for you, it can help determine the tradeoffs involved in designing for the level you choose.

Over extended time periods, for example, the model can determine how you can change major performance parameters and maintenance techniques to keep a single-error-correcting system's failure (double-bit-hit) probability lower than a target value. When using this procedure, you vary one system characteristic while holding all others constant. Then, at specific time intervals, the computerized model calculates the system failure probability to determine the characteristic's influence on system reliability.

Data accumulated from implementing this scheme shows that performance parameters and maintenance techniques generally affect memory-system reliability in several ways:

- Increasing memory size by increasing the total number of storage devices degrades reliability.
- Although larger word sizes require proportionately fewer error check bits, elongating word length decreases reliability.
- Higher density storage devices can have higher per-device soft- and hard-error rates without degrading reliability, so long as per-bit error rates don't increase.
- Without hard- or soft-error maintenance, an increase in the device error rate results in downgraded reliability.
- An increase in the average percentage of device lost from a hard error decreases reliability.
- By choosing the appropriate maintenance intervals, you can compensate for the effects of degraded reliability.

To place this information in perspective, the graphical plots presented here summarize memory-system reliability factors clearly and simply. Each plot's vertical axis indicates double-bit-hit probability—the reliability measure assumed in Part 1. The horizontal axis tracks system operation time in days.

Larger systems lead to lower reliability

The first system-parameter analysis focuses on how memory size affects reliability. In **Fig 1,** the 256k-word curve represents the reference memory system introduced in Part 1. Observe that the two larger memory systems included in the graph yield a greater number of double-bit hits than does the smallest system. In fact, without error maintenance, the 64k-word system takes 16 times longer to accumulate as many hits as the 1024k-word system. And the double-bit-hit probability of the 64k-word system always stays much lower than those for the two larger systems.

The next parameter analysis considers word-size effects on memory-system reliability. **Fig 2** shows plots for three systems that each contain 512k usable storage

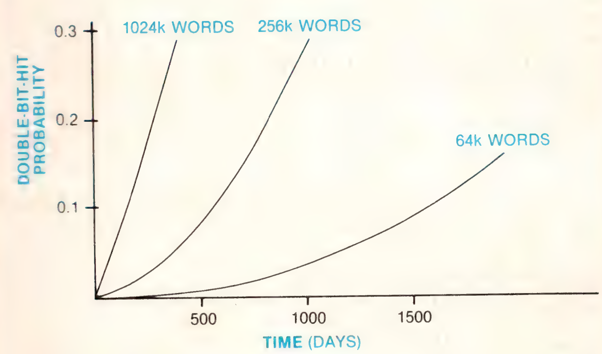

Fig 1—A 64k-word memory *yields a lower double-bit-hit probability than do 256k- and 1024k-word arrays. In fact, the 64k-word memory operates 16 times longer than the 1024k-word memory before it piles up the same number of double-bit hits.*

Large memory and word sizes downgrade system reliability

bytes. The 64k×72-bit system comprises a 64-bit data word plus eight check bits to accomplish single-error correction and double-error detection. Similarly, the 128k×39-bit system contains a 32-bit data word with seven check bits, and the 256k×22-bit reference memory system includes 16 data bits and six check bits.

As the curves for the systems illustrate, even if you decrease system size to compensate for a word-length increase, that increase boosts the double-bit-hit probability and decreases system reliability.

On the other hand, if you scale down the number of system words in proportion to the change in total word length—rather than in proportion to the number of information bits—total memory size will be larger than 64k and 128k. Because large memory systems perform less reliably than small ones (all other parameters being equal), the 72- and 39-bit reliability curves would shift farther to the left than shown in **Fig 2.**

Fewer errors come from denser devices

Next, consider component-density effects on memory-system reliability **(Fig 3).** The 16k-RAM curve models the reference memory system, which contains 16k×1-bit dynamic RAMs.

Because the soft- and hard-error rates per device in **Fig 3** are held constant relative to all the component densities, the systems with denser components yield proportionally fewer errors. Consequently, systems using denser devices achieve higher reliability levels than do systems with a larger number of less dense devices—so long as all the devices are subject to the same total error rate.

Thus, when you upgrade a system with denser devices, it can tolerate higher per-device soft- and hard-error rates. In fact, the per-bit error rates become more significant than the per-device rates in determining system reliability. For example, when you substitute 64k×1-bit devices for 16k×1-bit parts, the denser system can tolerate four times as many soft errors and failed bits per device per unit time than the less dense system, without affecting system reliability.

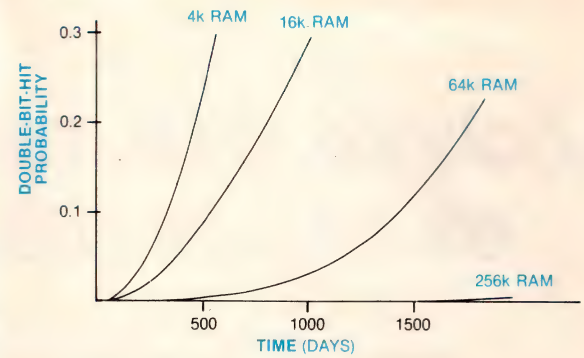

Fig 3—When subjected to the same per-device hard- and soft-error rates, *memory systems containing dense memory devices (eg, 64k and 256k RAMs) experience fewer total errors than do those with less dense devices (eg, 4k and 16k RAMs). Thus, use of denser devices with equal per-device error rates results in memory systems having higher reliabilities.*

Soft errors add up to trouble

Needless to say, not all memory devices are subject to the same soft- and hard-error rates. You could reasonably expect 64k dynamic RAMs, for example, to be more susceptible to alpha radiation, and hence exhibit more soft errors, than 16k RAMs.

In this regard, **Fig 4** shows soft-error-rate effects on system reliability. The 0.1%/1k-hrs curve models the reference memory system. The other four curves illustrate other system soft-error rates ranging from 0 to 1% per 1000 hrs.

Not surprisingly, the systems with higher soft-error

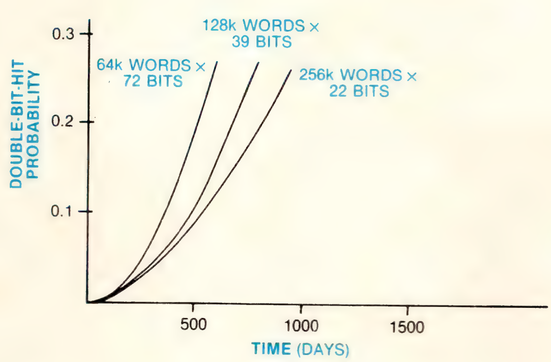

Fig 2—Although wider words *need proportionately fewer check bits for error correction (64, 32 and 16 data bits require eight, seven and six bits for single-error correction with double-error detection, respectively), systems employing them run the risk of higher double-bit-hit probabilities.*

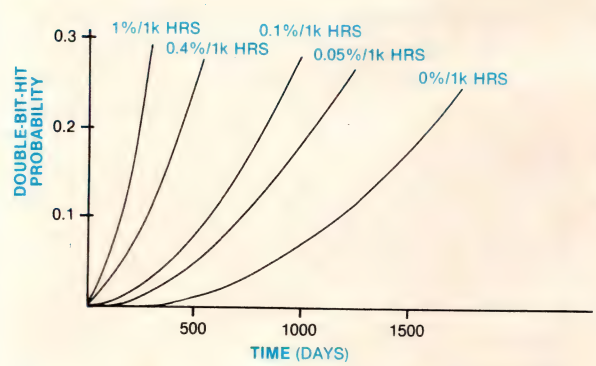

Fig 4—High soft-error rates *(eg, 1% per 1000 hrs) have a relatively strong effect on memory-system reliability. Of particular interest, the 0%/1k-hr curve represents a memory system that experiences only hard errors.*

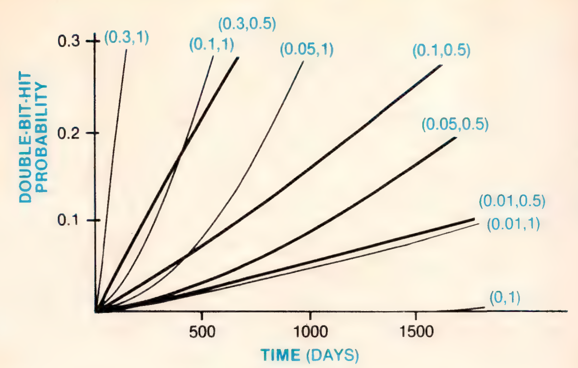

Fig 5—Curves show the effects of varying hard-failure rates *on memory-system reliability. The two terms in parentheses for each curve represent the Weibull distribution's 100/α and β characteristics. As the 100/α (first) term increases, the overall hard failure rate also increases and in turn decreases system reliability. The β (second) term affects the curve's shape.*

rates are less reliable than otherwise identical systems with lower rates. For comparison, the 0%/1k-hrs curve represents a system with no soft errors; its double-bit-hit probability results entirely from hard errors.

To analyze another key parameter, **Fig 5** exhibits a host of curves that monitor the effects of hard-error rates on memory system reliability. A set of two Weibull-distribution terms in parentheses accompanies each curve. The first term—which corresponds to the Weibull distribution's 100/α characteristic—is the A value given in Part 1's computer program. When the hard-error rate is constant, this term expresses the hard-error rate in percent per 1000 hrs.

The set's second term stands for the Weibull distribution's β (or B in the computer program) characteristic. When β equals 1, for example, the hard-error rate stays constant over time. When β equals 0.5—a common value for memory devices—the distribution reflects an infant-mortality mechanism.

All the **Fig 5** curves show the effects of varying both α and β. The bold-line curves represent the β-equals-0.5 cases, whereas the fine-line curves indicate the β-equals-1 cases. The reference (0.05, 1) curve represents a constant 0.05%-per-1000-hr hard-error rate.

Note from these curves that increasing the Weibull set's first term increases the overall system hard-error rate and shifts the curves to the left. Note, too, that varying the second term (β) changes the curves' shapes. Specifically, the β-equals-0.5 curves tend to be flatter than the β-equals-1 curves because their hard-error rates decrease with time. In fact, for a constant α, the β curves cross eventually, just as do the instantaneous hard-error-rate curves.

The (0,1) curve represents a system with no hard errors; its double-bit-hit probability originates from soft errors alone. This probability remains near zero because of the relatively small number of total bits lost due to soft errors. In contrast, the relatively large number of bits lost per hard error would cause the 0%/1k-hrs curve in **Fig 4** to yield a somewhat higher double-bit-hit probability, where only hard errors exist.

Reliability goes down as device loss goes up

Another parameter analysis covers the effects of different percentages of device lost due to a hard error (**Fig 6**). The 10% curve stands for the reference memory system. Obviously, with an increase in loss percentage, the total number of bits affected by hard errors increases and system reliability decreases.

To simplify the foregoing parameter analyses, the system-reliability calculations assume that a memory system has received no periodic maintenance. **Fig 7,** however, illustrates the effects of adding hard-error maintenance and soft-error scrubs to the reference memory system. The smooth reference-system curve shows system reliability without soft-error scrubs or hard-error maintenance. The other three jagged curves illustrate the effects of adding periodic hard- and soft-error maintenance individually and in combination.

Consider first the effects of adding soft-error scrubs only. Write cycles and read/modify/write cycles associated with normal memory activities accomplish some nonperiodic soft-error maintenance in many systems. In fact, a virtual memory system that allows paging can be modeled as having an inherent soft-error scrub, whose rate depends on the interval in which all pages are swapped. For simplicity here, however, soft-error maintenance refers to scheduled periodic soft scrubs only.

The 90-day-soft-scrub-only curve in **Fig 7** outlines the effects of performing a soft-error scrub on the reference memory system. The curve's jagged nature results from the decrease in double-bit-hit probability every 90 days when the scrub occurs. Note that after each scrub, the lower points on this curve track the corresponding points on the 0%/1k-hrs curve in **Fig 4,** which models a memory system with no soft errors. The slight difference between the two curves results

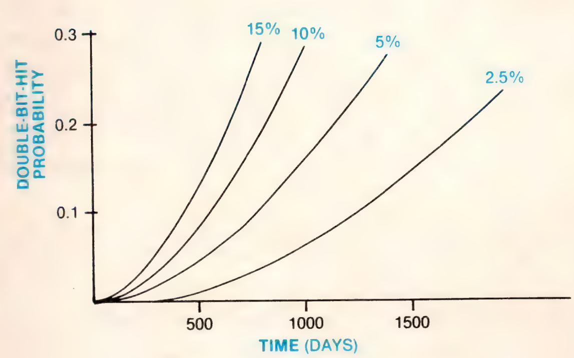

Fig 6—From these curves showing the percentages of device lost *due to hard errors, observe that when the percentage increases, the probability of a system failure also increases.*

Dense storage devices yield fewer total errors

from the small probability of one or more soft errors occurring within the 90-day period between scrubs. Because the mean time between soft errors in the reference memory system equals 118 days (as calculated in Part 1), using shorter scrub intervals achieves only modest reliability gains—a few percentage points at best.

Hard-error maintenance helps even more

The foregoing analysis examines soft-error-scrub effects without hard-error maintenance. But because you must perform a rewrite after replacing failed devices, soft-error scrubs usually occur whenever hard-error maintenance is performed.

On the other hand, a memory-deallocation maintenance technique eliminates all hard errors but relatively few soft errors. Although this article doesn't present separate data for a memory-deallocation maintenance example, those results closely resemble that of a system with simple hard-error maintenance. Any differences could be traced to total available memory-size changes resulting from the use of the memory-deallocation technique.

The 90-day-maintenance-only curve shown in **Fig 7** presents the effects of performing hard-error maintenance every 90 days. The curve is jagged like the soft-scrub-only curve because the double-bit-hit probability decreases after you remove hard failures from the system. The sawtooth shape becomes even more pronounced with hard-error maintenance because you repair more bits when eliminating hard failures than you do correcting single-bit soft errors. After each maintenance, the lower points on this curve track **Fig 5**'s (0, 1) curve, which models a system with no hard errors.

Note in **Fig 7** that the 90-day-maintenance-only curve rises proportionately higher than the 90-day-soft-scrub-only curve after each maintenance period. This difference arises because a hard error that occurs within the 90 days between maintenance periods generally affects a proportionately larger number of bits than does a soft error. Carefully choosing hard-error-maintenance periods appears to be more significant, therefore, than choosing soft-error-scrub intervals.

The 90-day-maintenance-plus-90-day-soft-scrub curve shows the effects of applying both hard- and soft-error maintenance to the reference memory system. Even when you perform both types of error maintenance only every 90 days, you can still keep the double-bit-hit probability below 1 or 2%. In other words, you can preserve the high reliability of memory arrays that employ error correction by choosing appropriate soft- and hard-error maintenance intervals.

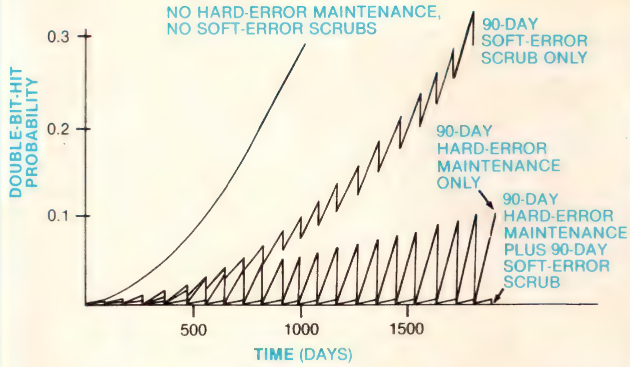

Fig 7—Adding error-maintenance capabilities *and employing them on a periodic basis changes the reference memory system's double-bit-hit probability from a smooth curve to a set of lower value sawtooth-shaped ones exhibiting improved reliability.*

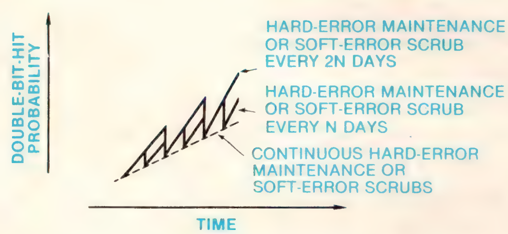

Fig 8—Very large memory systems *generally experience increased reliability with relatively short hard- or soft-error maintenance intervals. For most other memory systems, though, shorter maintenance intervals can provide only a modest reliability improvement.*

Short maintenance intervals aid large systems

How do you determine the appropriate maintenance parameters for a memory system? Running Part 1's computer program with a variety of parameters to explore their reliability effects provides a good start.

With regard to shortening the hard- or soft-error maintenance intervals, however, the best reliability improvement you can obtain corresponds to approximately a memory system's lowest double-bit-hit curve with no hard or soft errors, respectively. You can smooth the curves' jagged nature with short and ultimately continuous maintenance intervals, though. **Fig 8** illustrates these effects in a general sense.

For a given memory system, though, a surprisingly long soft-error-scrub or hard-error-maintenance interval might achieve an acceptable system-reliability level. And note that additional or shorter-interval maintenance proves most valuable in large memory systems—those composed of storage devices with high error rates—and in systems requiring a high reliability level. **EDN**

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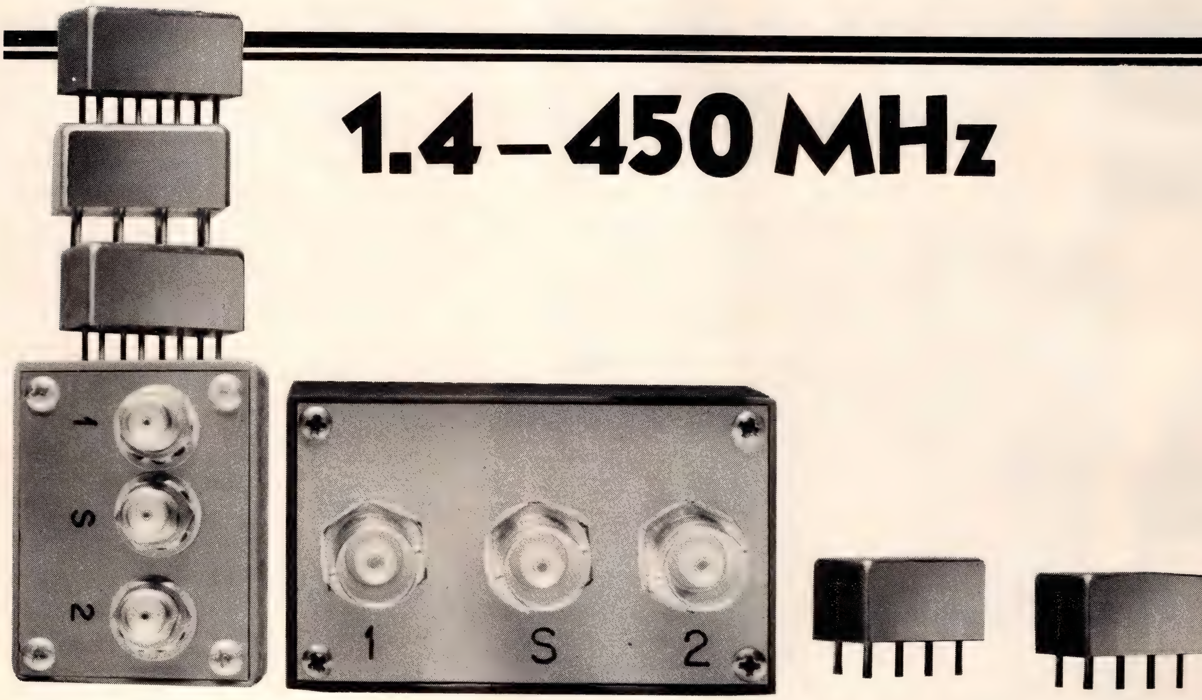

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Parallel-to-serial scheme increases ROM speed

Marian Stofka
Bratislava, Czechoslovakia

When your design's speed performance is bound by ROM access time, consider the concept depicted in **Fig 1.** If the design employs successive ROM addressing—as is the case in waveform-generation equipment—a parallel-to-serial ROM organization can improve speed by at least a factor of two.

Fig 1's block diagram illustrates the parallel-addressing scheme employed in this concept. In addition to being addressed in parallel, the ROMs' outputs are also sampled in parallel by fast, edge-triggered memory registers just before new data is required. These registers have 3-state or open-collector outputs to simplify the parallel-to-serial conversion. (The appropriate outputs are wire-ORed to create the output lines.)

K words stored in the registers thus emerge at a rate K times that of the address generator. You provide the register's output-enable control (OC) by decoding the divide-by-mod-K counter's output; the

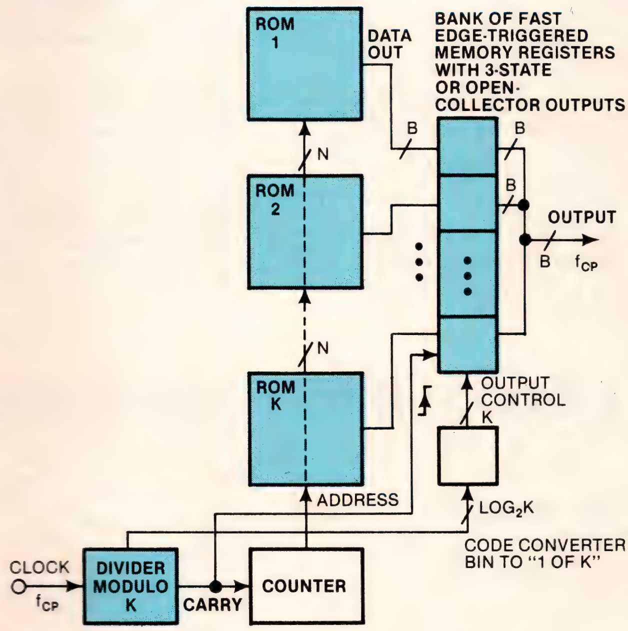


Fig 1—Parallel-addressing K ROMs *increases their apparent speed by a factor of K. The 3-state output registers are output enabled by decoding the divide-by-K counter's output.*

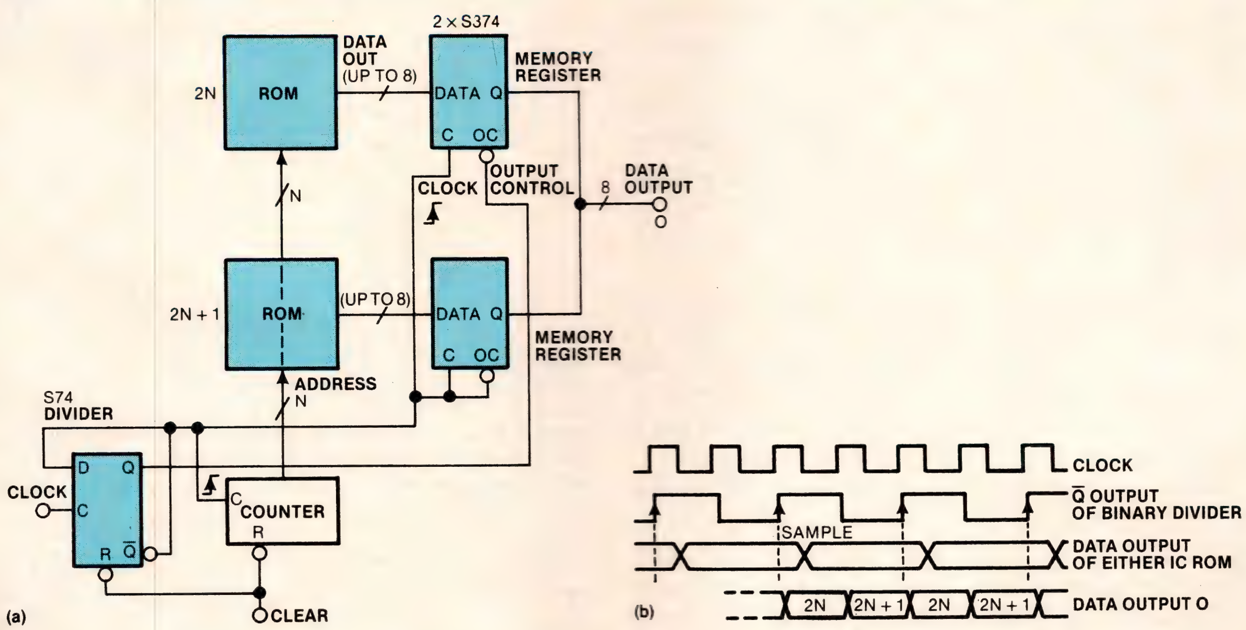


Fig 2—A hardware realization *of a ROM-speed-up concept* **(a)** *can at least double your data's throughput rate. With this technique, you can reduce the ROM system's effective address time (and therefore data-output time) by a factor of K. In the example shown, the divide-by-2 approach results in the alternating ROM outputs defined in* **(b).**

ROM's address generator/counter comes from the divider's Carry output.

The ROM system's data is organized so that at any address location, each ROM contains one word of a group of K succeeding words. As a result, the array has an effective address time only 1/K that of a single ROM. Total ROM capacity remains unchanged, though: K ROMs with a $2^N \times B$ organization become a $K2^N \times B$ format.

The configuration shown in **Fig 2** uses these ideas to achieve a factor-of-two speed improvement. (You can extend the concept to suit your needs.) The ROMs' data outputs go to the inputs of 8-bit, high-speed, edge-triggered memory registers that have 3-state outputs. ROM 2N contains the even-numbered words; ROM 2N+1, the odd-numbered ones. The ROMs' output data transfers to the memory registers as a result of the LOW-to-HIGH transitions appearing at the divider's inverting output.

The clock-driven divider drives the ROM address generator and simultaneously enables the memory registers in an alternating mode. (Note that the data output at point O is delayed by two clock cycles with respect to the start of addressing.) The organization resulting from a $2^N \times 8$ format is $2^{N+1} \times 8$. **EDN**

To Vote For This Design, Circle No 450

Lamp dimmer forms motor controller

H O Winters
IBM Corp, Boulder, CO

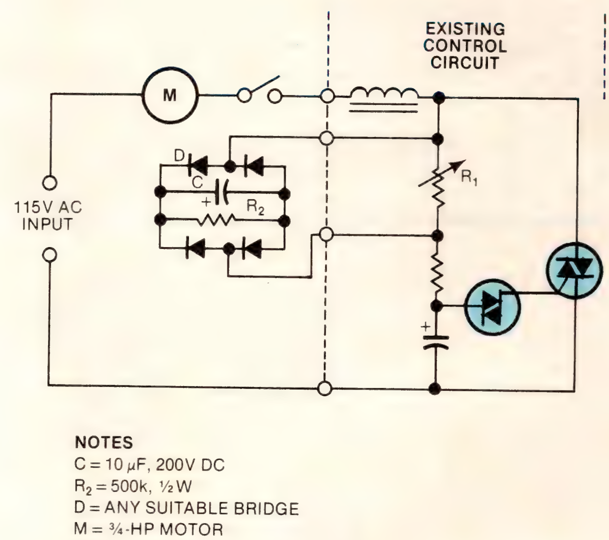
Common household devices such as fans and furnace blowers load ac induction motors fairly constantly once they're up to speed. However, these devices aren't really very efficient—in terms of necessary input power—when running under these conditions. And designs that increase their running efficiency are apt to be costly and complex when they must also start the motor.

The design illustrated in the **figure** solves this problem at a very reasonable cost. The lamp dimmer costs approximately $5; the additional components, $2. Employed in conjunction with a furnace blower, the circuit has saved 11.5% of the blower's energy consumption.

The modified lamp dimmer starts the induction motor at full power. Then, after a time delay, it reduces the motor's input power. As shown, the circuit can directly control motors rated as high as ⅓ hp. And you can increase this level by employing a higher current triac as the prime control device.

Capacitor C presents a low-impedance shunt to the level-set potentiometer R_1, supplying full power to the motor during the start-up phase. As this capacitor charges, the applied power gradually reduces to the level set by R_1. When the power turns off, bleeder resistor R_2 discharges C, and you can restart the motor in approximately 5 sec.

To set up a motor using this controller, first start the motor R_1 set fully clockwise for maximum power.



Economical motor control *results when you make these low-cost additions to a standard triac-controlled lamp dimmer. Capacitor C effectively shorts out the speed-control pot (R_1) until the induction motor has fully started. Then the motor runs at reduced speed but with increased efficiency.*

Then slowly reduce power until the motor slows noticeably but keeps running. Finally, increase power until the motor resumes running at full speed at a smooth, quiet level. **EDN**

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Battery charger snaps from full to trickle

Kennan C Herrick
ESI Electronics Corp, San Francisco, CA

The best way to manage lead-acid-battery charging is to supply a constant current until you reach a prescribed cell voltage, then lower the voltage to maintain "float" charging. As a rule of thumb, the charging current should be no more than one-fourth of the battery's ampere-hour rating. Additionally, the battery's fully charged voltage is about 2.4V/cell; the float voltage should be approximately 90% of that value.

The circuit shown in **Fig 1a,** simpler than most, provides these functions adequately. Although designed for a 12V, 5-Ahr lead-acid battery, it adapts to batteries with other voltage and current ratings. The programmable IC regulator (IC_1) and transistor Q_1 provide a relatively constant current until the battery voltage reaches the fully charged value. Transistor Q_2 then senses this condition and drops the regulator's output voltage to the float value.

IC_1's output voltage is set by the ratio of R_3 to R_5+R_6, where R_6 adjusts for the exact output voltage desired. You can find this output voltage by using

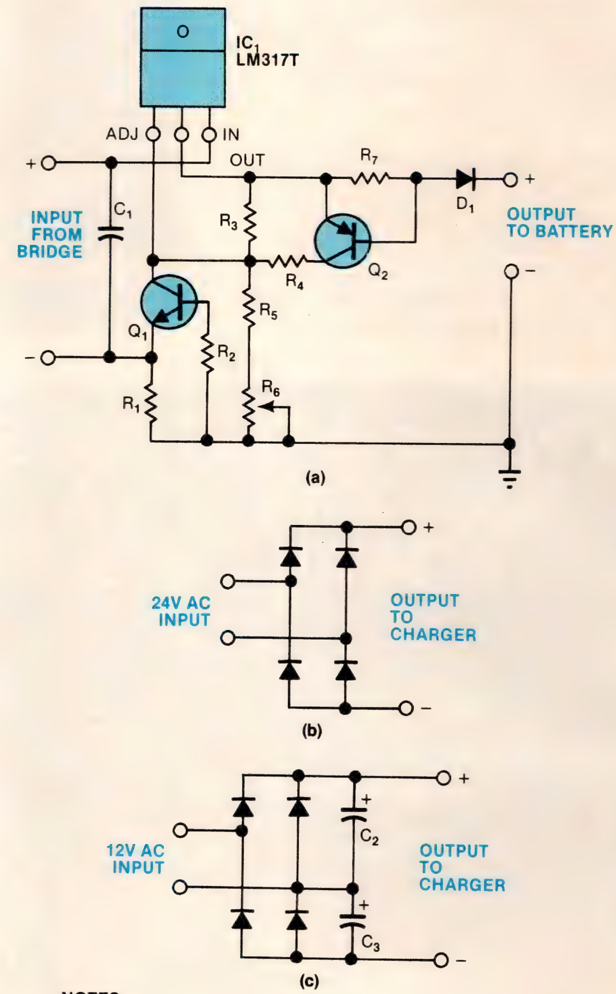
$$V_{REG}=V_{REF}(1+((R_5+R_6)/R_3))+I_{ADJ}(R_5+R_6)$$

where V_{REG} is Q_2's emitter-node voltage and V_{REF} is the nominal 1.25V reference voltage maintained by IC_1 across R_3. IC_1's Adj pin supplies I_{ADJ}, a nominal 100 μA. Note that the R_3 used in the equation can be either R_3's value alone or the effective value of R_3 paralleled by R_4.

In the Charging mode, Q_2 is ON, thanks to the emitter-to-base charging current. R_4 thus parallels R_3, and IC_1's V_{REG} equals 16V (with nominal circuit values and R_6 set near mid-resistance). Subtracting a typical D_1 drop of 0.7V and Q_2 emitter-base drop of 0.7V provides 14.6V. When the battery voltage rises to this value—signifying full charge—Q_2 starts to turn off (**Fig 2,** point A). At this time, with Q_2's base current approaching zero, the remaining charging current (through R_7) is approximately 30 mA.

As Q_2 turns off, R_4 becomes disconnected from R_3, the R_5/R_6 current decreases, V_{REG} (at Q_2's emitter) falls and Q_2 turns off further. This transition to the float voltage is regenerative and abrupt (**Fig 2,** point A to point B, then point B to point C as the battery voltage declines to the float value).

Float V_{REG} is 14.5V with Q_2 OFF. Subtracting 0.6V for D_1's drop (at low current) and a few tenths of a volt across R_7 yields a float battery voltage of about 13.7V. The circuit maintains this voltage until the battery voltage drops the several additional tenths of a volt necessary to cause Q_2 to turn on (**Fig 2,** point D). Q_2 stays ON (**Fig 2,** point E), and charging continues until the battery's voltage again reaches 14.6V.



NOTES
$R_1=5$
$R_2=68$
$R_3=240$
$R_4=2k$
$R_5=2.2k$
$R_6=500$, VARIABLE
$R_7=15$
$C_1=0.1\ \mu F$
$C_2=C_3=470\ \mu F$, 20V
$Q_1=2N2222$
$Q_2=TIP\text{-}34$
DIODE BRIDGE = MDA920A-1
D_1 = ANY SUITABLE 500-mA DIODE

Fig 1—Battery charging switches from full to float *when the combined D_1 and Q_2 V_{BE} voltage drops are reduced as the battery reaches its fully charged potential. At this time, Q_2 turns off and R_4 no longer parallels R_3, an action that reduces the charging-current rate. Depending on the transformer type you use, one of the bridge circuits (**(b)** or **(c)**) provides the required input voltage.*

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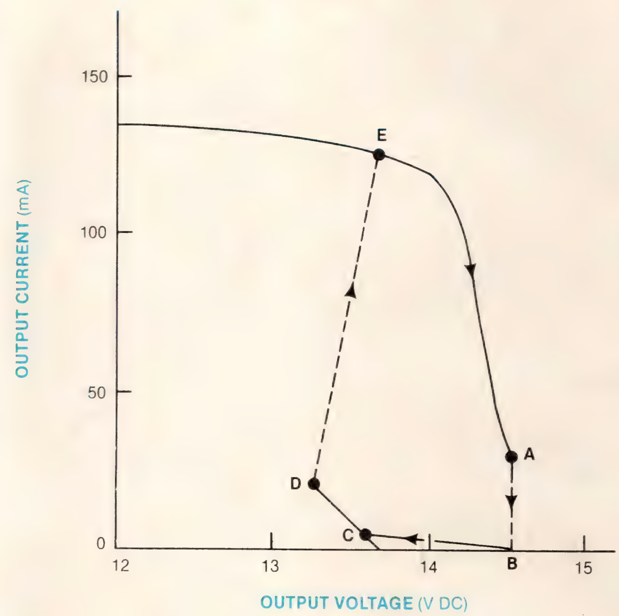

Fig 2—Full charging continues *until the battery's voltage reaches the "topped-up" level (A). At this point,* **Fig 1a***'s circuit rapidly reverts to a trickle-charge mode (points B through D) until the battery is sufficiently discharged. Full charging again occurs when the circuit switches back to point E operation.*

Nominal constant-current charging is Q_1's function. Charging current through R_1 tends to turn Q_1 on at a value of about 600 mA, in turn causing IC_1's output voltage to diminish to maintain that current. (This procedure works because IC_1's adjustment node is pulled toward ground.)

You can modify the design for a different battery voltage merely by changing the ratio of R_3 to R_5/R_6. Select R_4 to provide the desired float-vs-charging-voltage differential. R_7 determines the minimum charging current; the charging current itself—up to near the full battery charge—is set by R_1.

Because this design works just as well with a pulsating input from the diode bridges shown **(Figs 1b** and **1c),** you probably won't need to employ any additional filter capacitors. However, National Semiconductor (IC_1's manufacturer) does recommend using a large-value capacitor to absorb possible ac-mains transients. You can adjust a pulsating charging current upward to compensate for the less-than-100% duty cycle by choosing the proper value for R_1. Note that if you adapt this design for higher charging currents, Q_2's base must be able to handle the full charging current safely. **EDN**

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The unique design also allows for easy use. You can set up a program in minutes either with a program from the device library or with the complete test menu of fill-in-the-blanks software. Just snap in the appropriate family board module and socket module, plug in the device and press "GO"— the LTS-2000 does the rest. There's even a full-edit capability, so test parameters can be changed quickly and easily.

IT'S THE MOST VERSATILE BENCHTOP YOU CAN BUY.

You can not only use the LTS-2000 for incoming inspection, but component selection and grading, engineering analysis, quality control, final test, qualification test, and even as a diagnostic tool for component evaluation.

Never before has a compact benchtop linear test system offered so much versatility for so little. For more information on the LTS-2000, or the LTS-2010 which lets you program in BASIC, contact Greg LaBonte at (617) 329-4700, Analog Devices, P.O. Box 280, Norwood, MA 02062.

AND WE CAN DELIVER.

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ANALOG DEVICES

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Analog Devices, Inc., Box 280, Norwood, MA 02062; East Coast: (617) 329-4700; Midwest: (312) 894-3300; West Coast: (714) 842-1717; Texas: (214) 231-5094; Belgium: 031/37 48 03; Denmark: 02/84 58 00; England: 01/941 0466; France: 01/687 3411; Germany: 089/53 03 19; Japan: 03/263 6826; Netherlands: 076/87 92 51; Switzerland: 022/31 57 60; and representatives around the world.

1981 EDN CARAVAN ELECTRONIC SHOW TOUR
February 16 to March 27 (first half)

DATE	TIME	SITE
2/16 Monday	9-12 AM	ROCKWELL INT'L AUTONETICS 3370 Miraloma Ave., Anaheim, CA
2/16 Monday	2-4 PM	NORTHROP CORPORATION 500 East Orangethorpe, Anaheim, CA
2/17 Tuesday	8:30-11:30 AM	HUGHES AIRCRAFT Company 1901 W. Malvern Ave., Fullerton, CA
2/17 Tuesday	1-3 PM	BECKMAN INSTRUMENTS, INC. 2400 Harbor Blvd., Fullerton, CA
2/17 Tuesday	3:30-4:30 PM	BECKMAN INSTRUMENTS, INC. 200 So. Kraemer Blvd., Brea, CA
2/18 Wednesday	8:30-10 AM	INTERSTATE ELECTRONICS CORPORATION 707 E. Vermont Ave., Anaheim, CA
2/18 Wednesday	10:30-12 AM	INTERSTATE ELECTRONICS CORPORATION 1001 Ball Rd., Anaheim, CA
2/18 Wednesday	2-3:30 PM	CALIFORNIA COMPUTER PRODUCTS 2411 W. La Palma, Anaheim, CA
2/19 Thursday	8:30-9:30 AM	COMPUTER AUTOMATION 18551 Von Karman Ave., Irvine, CA
2/19 Thursday	10:30-12 AM	MICRODATA CORPORATION 1562 Reynolds Ave., Irvine, CA
2/19 Thursday	2-4 PM	SPERRY UNIVAC MINI-COMPUTER 16842 Von Karmon Ave., Irvine, CA
2/20 Friday	9-11:30 AM	FORD AERO & COMMUNICATIONS CORPORATION Ford Rd., Newport Beach, CA
2/20 Friday	1:30-3:30 PM	ROCKWELL INT'L COLLINS 4311 Jamboree Rd., Newport Beach, CA
3/2 Monday	9-11 AM	HEWLETT-PACKARD COMPANY 1501 Page Mill Rd., Palo Alto, CA
3/3 Tuesday	1-2 PM	DIGITAL TELEPHONE SYSTEMS 1 Commerce Blvd., Novato, CA
3/2 Monday	1-3 PM	AMPEX CORPORATION 401 Broadway, Redwood City, CA
3/3 Tuesday	9-11:30 AM	HEWLETT-PACKARD COMPANY 1400 Fountain Grove, Santa Rosa, CA
3/3 Tuesday	3:30-4:30 PM	DIABLO SYSTEMS INC. 24500 Industrial Blvd., Hayward, CA
3/4 Wednesday	8:30-11:30 AM	LOCKHEED MISSILES & SPACE CO. 1111 Lockheed Way, Sunnyvale, CA
3/4 Wednesday	1-2 PM	ATARI INC. 1272 Borregas Ave., Sunnyvale, CA
3/4 Wednesday	2:45-4:30 PM	AMDAHL CORPORATION 1250 E. Arques Ave., Sunnyvale, CA
3/5 Thursday	9-11:30 AM	HEWLETT-PACKARD COMPANY 11000 Wolfe Rd., Cupertino, CA
3/5 Thursday	1-2 PM	APPLE COMPUTER CORPORATION 10460 Banley Dr., Cupertino, CA
3/5 Thursday	3-4:30 PM	SHUGART ASSOCIATES INC. 475 Oakmead Pkwy, Sunnyvale, CA
3/6 Friday	8:30-10 AM	FOUR PHASE SYSTEMS INC. 10700 N. De Anza Blvd., Cupertino, CA
3/6 Friday	11-12 AM	MEMOREX CORPORATION 18922 Forge Drive, Cupertino, CA
3/6 Friday	2-4 PM	ROLM CORPORATION 4900 Old Ironsides Dr., Santa Clara, CA
3/9 Monday	9-11 AM	HEWLETT-PACKARD COMPANY 5301 Stevens Creek Blvd., Santa Clara, CA
3/9 Monday	1-3:30 PM	MEMOREX CORPORATION San Tomas & Central Xway, Santa Clara, CA
3/10 Tuesday	8:30-1 AM/PM	IBM CORPORATION 5600 Cottle Rd., San Jose, CA
3/11 Wednesday	8:30-10 AM	GM DELCO ELECTRONICS 6767 Hollister Ave., Goleta, CA
3/11 Wednesday	10:30-12 AM	BURROUGHS CORPORATION 6300 Hollister Ave., Goleta, CA
3/11 Wednesday	2:30-4 PM	BURROUGHS CORPORATION 5411 N. Lindero Canyon, Westlake Village, CA
3/12 Thursday	9-11:30 AM	HUGHES AIRCRAFT COMPANY 8433 Fallbrook Ave., Canoga Park, CA
3/12 Thursday	1:30-4 PM	LITTON GUIDANCE & CONTROL SYSTEMS 5500 Canoga Ave., Woodland Hills, CA
3/13 Friday	8:30-9:45 AM	DATA PRODUCTS CORPORATION 6200 Canoga Ave., Woodland Hills, CA
3/13 Friday	10:45-12 AM	TELEDYNE SYSTEMS COMPANY 19601 Nordhoff St., Northridge, CA
3/13 Friday	2-4 PM	LITTON DATA SYSTEMS 8000 Woodley St., Van Nuys, CA
3/16 Monday	8:30-10 AM	BURROUGHS CORPORATION 460 Sierra Madre Villa, Pasadena, CA
3/16 Monday	11-12 AM	GOULD INC. 4323 Arden Dr., El Monte, CA
3/16 Monday	2-4 PM	NORTHROP CORPORATION 3901 W. Broadway, Hawthorne, CA
3/17 Tuesday	9-12 AM	HUGHES AIRCRAFT COMPANY 2000 E. Imperial Hwy., El Segundo, CA
3/17 Tuesday	1:30-4:40 PM	HUGHES AIRCRAFT COMPANY Centinella & Teale, Culver City, CA
3/18 Wednesday	9-11 AM	AMPEX CORPORATION 200 N. Nash, El Segundo, CA
3/18 Wednesday	1:30-4 PM	XEROX CORPORATION 701 So. Aviation Blvd., El Segundo, CA
3/19 Thursday	8:30-10 AM	BURROUGHS CORPORATION 25725 Jeronimo Rd., Mission Viejo, CA
3/19 Thursday	11-12 AM	HUGHES AIRCRAFT COMPANY 6155 El Camino Real, Carlsbad, CA
3/19 Thursday	2:30-4:30 PM	CUBIC CORPORATION 9233 Balboa Ave., San Diego, CA
3/20 Friday	8:30-9:30 AM	HEWLETT-PACKARD COMPANY 16399 W. Bernardo Dr., San Diego, CA
3/20 Friday	10-12 AM	NCR CORPORATION 16550 W. Bernardo Dr., San Diego, CA
3/20 Friday	2-4 PM	GENERAL DYNAMICS ELECTRONICS 5011 Kearney Villa Rd., San Diego, CA
3/23 Monday	8-9 AM	HONEYWELL PROCESS CONTROL 16404 N. Black Canyon Hwy., Phoenix, AZ
3/23 Monday	9:30-12 AM	HONEYWELL INFORMATION SYSTEMS 13430 N. Black Canyon Hwy., Phoenix, AZ
3/23 Monday	2-4:30 PM	SPERRY FLIGHT SYSTEMS 21111 N. 19th Ave., Phoenix, AZ
3/24 Tuesday	9-12 AM	MOTOROLA GOV'T ELECTRONICS 8201 E. McDowell Rd., Scottsdale, AZ
3/24 Tuesday	2-3:30 PM	ITT COURIER 1515 W. 14th St., Tempe, AZ
3/25 Wednesday	9-11:30 AM	IBM CORPORATION Tucson, AZ
3/25 Wednesday	1:30-4 PM	HUGHES AIRCRAFT COMPANY Nogales Hwy., Tucson, AZ
3/27 Friday	1:30-4 PM	SPERRY UNIVAC 322 N. 2200 West, Salt Lake City, UT

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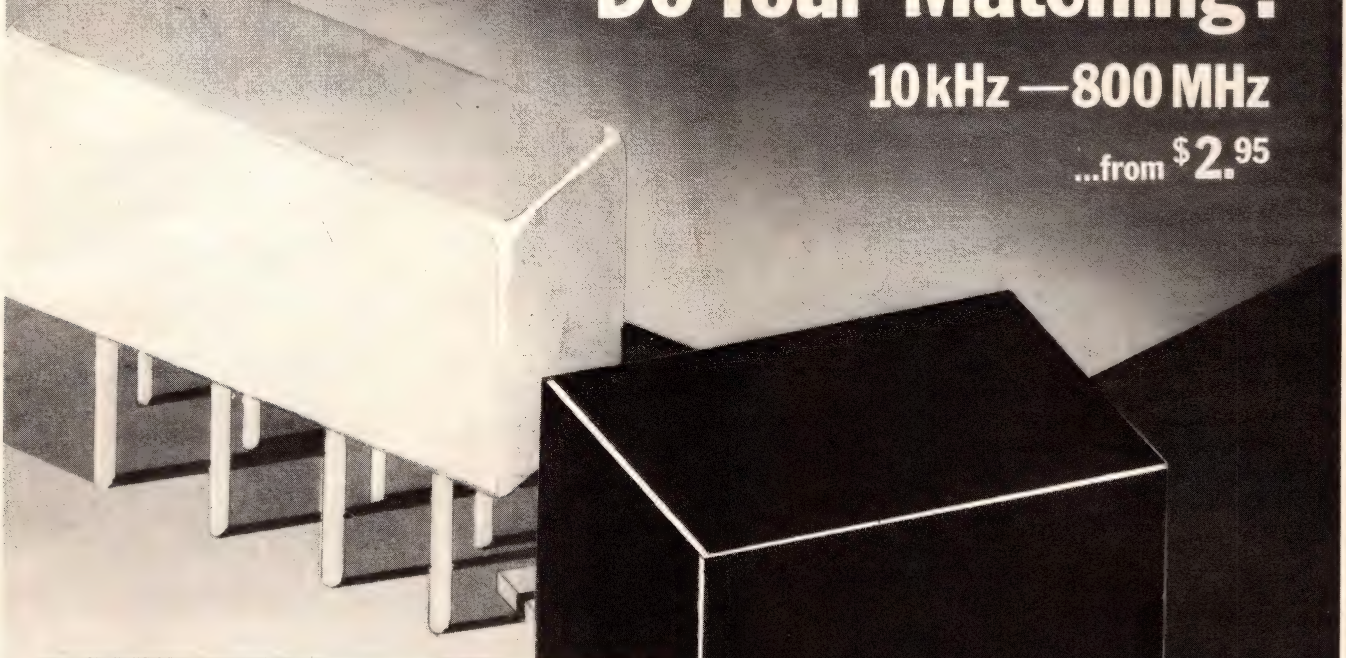

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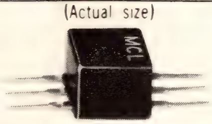
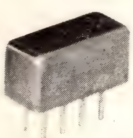


Models T, TH (Plastic case)
(0.300" sq. × 0.230" high)

(Actual size)



Model TMO (Metal case)
(.500" L × .230" w × .255" h)

DC ISOLATED PRIMARY & SECONDARY

Model No.	Imped. ratio	Freq. (MHz)	Price (10-49)
T1-1	1	.15-400	$2.95
TM01-1	1	.15-400	$4.95
● T1-1H	1	8-300	$4.95
T1.5-1	1.5	.1-300	$3.95
TM01.5-1	1.5	.1-300	$6.75
T2.5-6	2.5	.01-100	$3.95
TM02.5-6	2.5	.01-100	$6.45
T4-6	4	.02-200	$3.95
TM04-6	4	.02-200	$6.45
T9-1	9	.15-200	$3.45
TM09-1	9	.15-200	$6.45
● T9-1H	9	2-90	$5.45
T16-1	16	.3-120	$3.95
TM016-1	16	.3-120	$6.45
● T16-1H	16	7-85	$5.95

● Up to 100mA DC without saturation

CENTER-TAPPED DC ISOLATED PRIMARY & SECONDARY

Model No.	Imped. ratio	Freq. (MHz)	Price (10-49)
T1-1T	1	.05-200	$3.95
TM01-1T	1	.05-200	$6.45
T2-1T	2	.07-200	$4.25
TM02-1T	2	.07-200	$6.75
T2.5-6T	2.5	.01-100	$4.25
TM02.5-6T	2.5	.01-100	$6.75
T3-1T	3	.05-250	$3.95
TM03-1T	3	.05-250	$6.45
T4-1	4	.2-350	$2.95
TM04-1	4	.2-350	$4.95
● T4-1H	4	8-350	$4.95
T5-1T	5	.3-300	$4.25
TM05-1T	5	.3-300	$6.75
T13-1T	13	.3-120	$4.25
TM013-1T	13	.3-120	$6.75

UNBALANCED PRIMARY & SECONDARY

Model No.	Imped. ratio	Freq. (MHz)	Price (10-49)
T2-1	2	.025-600	$3.45
TM02-1	2	.025-600	$5.95
T3-1	3	.5-800	$4.25
TM03-1	3	.5-800	$6.95
T4-2	4	.2-600	$3.45
TM04-2	4	.2-600	$5.95
T8-1	8	.15-250	$3.45
TM08-1	3	.15-250	$5.95
T14-1	14	.2-150	$4.25
TM014-1	14	.2-150	$6.75

FOR ADDITIONAL INFORMATION, COMPLETE SPECIFICATIONS, AND PERFORMANCE CURVES, REFER TO 1979-80 MICROWAVES' PRODUCT DATA DIRECTORY pgs. 161 to 368 or 1979 EEM 2770 to 2974.

It's easy to transform impedance and reduce VSWR.

Chose from 40 models, 12.5 to 800 ohms, 10 kHz to 800 MHz, ultra- low distortion (H models) balanced, unbalanced and center-tapped . . . immediate delivery . . . at prices that can't be matched, starting at $ 2.95

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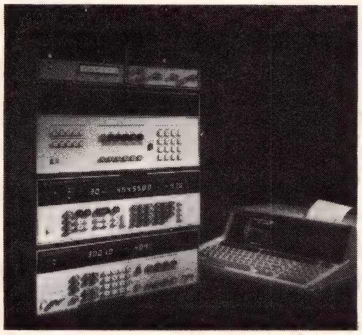
R 42/Rev/A

For more information, Circle No 75

New Products

INSTRUMENTATION & POWER SOURCES



TEST SET. Model 8903-E85 semiautomatic transceiver test set makes in-channel tests from AM, FM and PM communication transceivers from 150 kHz to 990 MHz, either automatically under control of an HP 85F controller or manually using instrument front-panel keyboard entry.

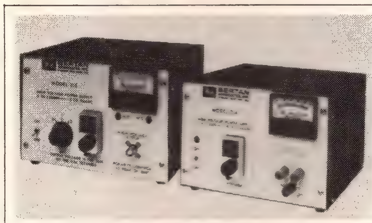
Its measurement capabilities range from simple tests such as frequency and distortion through complex measurements including usable sensitivity and audio flatness.

Providing an HP 8903A audio analyzer, HP 8901A modulation analyzer, HP 8656A synthesized signal generator, a switching module and a relay actuator, the μP-controlled unit is fully programmable and includes an HP-IB (GPIB) interface for remote control by the instrument controller.

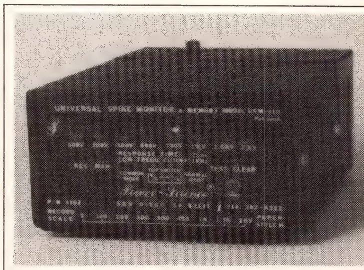
The modulation analyzer can measure AM depth or FM deviation to 1% accuracy in <2 sec with one keystroke or instruction and furnishes selectable FM de-emphasis filters; post-detection audio filters; and peak, peak-hold and average detectors. The audio analyzer similarly performs a SINAD measurement with typical residual noise and distortion of <0.003%.

The HP 11723A Application Pac software tape can be used to make 14 transceiver tests. $28,500. Delivery, 24 wks ARO. **Hewlett-Packard Co,** 1507 Page Mill Rd, Palo Alto, CA 94304. Phone (415) 857-1501. **Circle No 172**

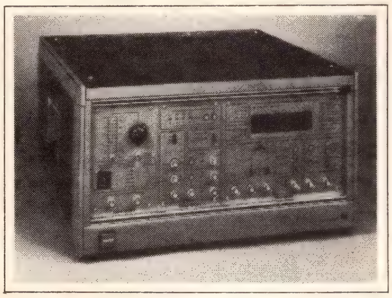
INTERFERENCE ANALYZER. Conforming to the quasi-peak-measurement standards of CISPR, VDE and ANSI Standard C63.2-1980, Model CPR-25 measures EMI utilizing LCDs that represent attenuation setting and show tuned frequency to an accuracy of ±0.1% over a 10-kHz to 1000-MHz range. It also incorporates circuits for detecting peak, average and rms levels and ratios that can be displayed on an 80-dB front-panel meter or tracked by single- or dual-pen X-Y plotting. Additionally, video response over each octave-range band can be presented on any conventional or storage-type oscilloscope, implementing a tuned - front - end spectrum-analyzer capability. $27,900. Delivery, 90 to 120 days ARO. **Penril Corp,** 5520 Randolph Rd, Rockville, MD 20852. Phone (301) 881-8151. TWX 710-828-0522. **Circle No 173**



POWER SUPPLIES. For precision laboratory high-voltage applications, these solid-state benchtop 5×7⅝×7¼-in. units feature digital voltage controls with a resolution of 200 mV, a front-panel voltage meter, regulation and ripple of 0.001%, TCs of 50 ppm/°C, plug-in pc boards and encapsulated high-voltage circuitry. They are arc protected, self restoring and claimed to be short-circuit proof. Model 214 has a floating output and can serve as a positive or negative source delivering 0 to 1000V at 15 mA. Model 215 provides a polarity switch with LED polarity indicators and an output of 0 to ±3000V at 5 mA. $485 for either model. **Bertan Associates Inc,** 3 Aerial Way, Syosset, NY 11791. Phone (516) 433-3110. **Circle No 174**

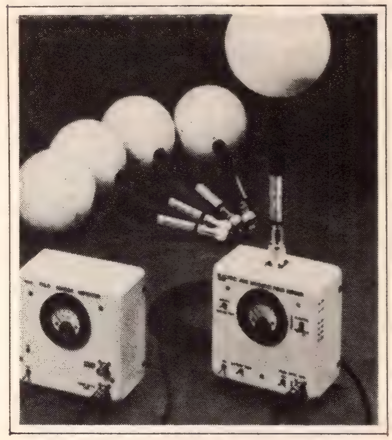


SPIKE MONITOR. Measuring peak amplitude of normal- and common-mode power-line spikes in eight discrete levels of 100V to 2 kV, the Universal Spike Monitor stores the result in a voltage-sensitive shift register and displays it on eight corresponding LEDs on its front panel. Measurement response time equals 25 nsec, and a 1-kHz cutoff network rejects low-frequency disturbances such as surges, sags or dropouts, forming an effective spike-monitor window of approximately 1 kHz to 10 MHz. The unit provides two modes of operation. In the Monitor mode, memory is instantly updated to hold (and display) the worst-case spike amplitude indefinitely until cleared by a front-panel pushbutton. In Recording mode, the memory produces a proportional dc current for a strip-chart recorder, clearing itself automatically after 1 min when a spike has been registered. $445; strip-chart recorder, $685. **Power-Science Inc,** 7667 Vickers St, San Diego, CA 92111. Phone (714) 292-4322. **Circle No 175**



BER INDICATOR. Providing bit-error-rate measurements to 325 MHz, the modular BERTS-325C includes a clock source, transmitter and receiver that generate pseudorandom or fixed-word patterns for stimulating the system under test and measure the bit-by-bit errors received. BER or total errors can be measured on continuous or burst data for applications such as TDMA testing. Data and delayed-data outputs are furnished for QPSK-test applications. A printer output is standard, and an optional GPIB interface permits automated-test applications. The transmitter provides four pseudorandom test patterns (2^7-1, $2^{15}-1$ and $2^{23}-1$ bits) and four 16-bit words, including alternating ONE/ZERO. Errors can be injected internally at a 2×10^{-2} BER or at an externally controlled rate. For measurements on nonpseudorandom 16-bit patterns, an external reference-data input is provided. $17,195. Delivery, 8 to 10 wks ARO. **Tau-Tron Inc,** 27 Industrial Ave, Chelmsford, MA 01824. Phone (617) 256-9013. TWX 710-343-6781. **Circle No 176**

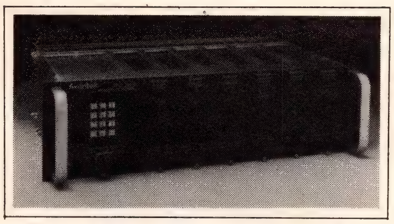
TEST SYSTEM. A minicomputer-controlled wafer-level parametric test system, System 300 can also be configured to test discrete semiconductor devices or functional circuits. It includes a PDP-11/23 minicomputer with 128k bytes of memory, dual floppy disks, a CRT or printing terminal and plug-in instrumentation modules for forcing dc current from 25 pA to 100 mA (to 250V) and dc voltage from 0.25 mV to 300V (to 1A). Standard modules provide voltage measurements from 100 μV to 250V and current measurements from 5 pA to 1A (0.01 pA with low-current matrix option). Capacitance measurement from 0.01 to 3000 pF FS is also available. Maximum matrix size is 144 pins, and the pins can be multiplexed to as many as four device test stations. A single measurement can be made in <3 msec; typical floating-point-calculation time equals 100 μsec. From $49,000. Delivery, 90 to 120 days ARO. **Keithley Instruments Inc,** 28775 Aurora Rd, Cleveland, OH 44139. Phone (216) 248-0400. TLX 985469. **Circle No 177**



RF-FIELD SENSOR. Manufactured by the Italian firm Aeritalia, this system uses balanced isotropic probes responding to any incident field (regardless of polarization) to provide a true reading of all incident electric or magnetic fields in the 1- to 500-MHz range. It comprises a shielded metering instrument with separate sensor probes and a field-sensor repeater connected to the metering device via fiber-optic cable. Three sensor probes cover electric field strengths from 10 to 100 V/m FS; two cover magnetic fields of 1 and 10 A/m FS. The repeater unit can be isolated from the incident field for remote-location readout. $7650 for metering instrument, repeater, fiber-optic link and five probes. Delivery, 60 to 90 days ARO. **Amplifier Research,** 160 School House Rd, Souderton, PA 18964. Phone (215) 723-8181. TWX 510-661-6094. **Circle No 178**

EPROM PROGRAMMER. For 25XX and 27XX Series EPROMs, the ROMMR erases, tests, programs and verifies 2708/58/16/32/64, 2516/32/64 and 68764 devices. It's available as an option to the maufacturer's Sprint 68 microcomputer/development system. $299. **Wintek Corp,** 1801 South St, Lafayette, IN 47904. Phone (317) 742-8428. **Circle No 179**

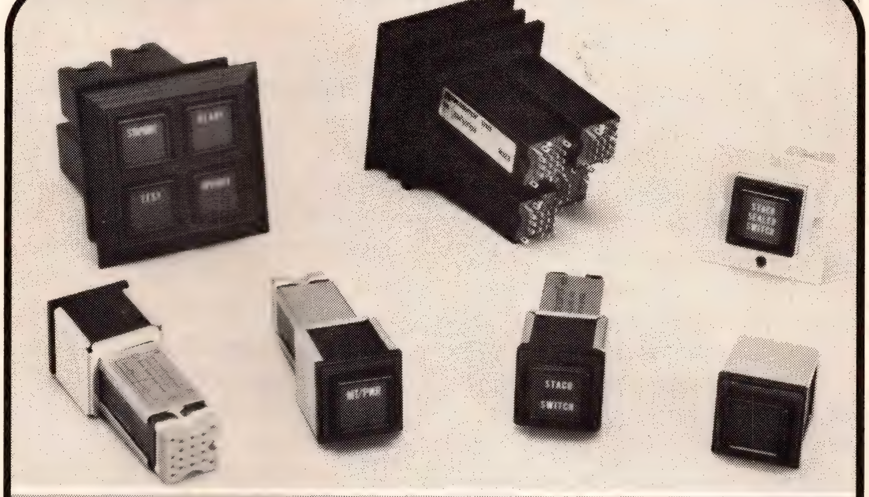
New Products



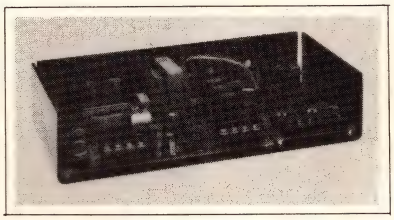
SATELLITE-VIDEO RECEIVER. You can receive any of the 24 video channels broadcast from SATCOM, WESTAR, COMSTAR or ANIK satellites with the Model AR1000 Simulchannel satellite-earth-station video receiving system. Equipped with an orthomode antenna feed, two LNA/down converters and separate horizontal and vertical feed lines, it can automatically select the correct feed line for a given transponder channel number (entered on a front-panel pad) to provide simultaneous access to six video channels. Other key features include PLL demodulation with threshold extension, automatic frequency control, digital channel selection and modular construction. Four receivers can be cascaded to provided simultaneous demodulation of 24 channels. Approximately $15,000 for 6-channel, 19-in.-rack-mounting unit with two LNA/down converters. Delivery, starting in May. **Avantek,** 3175 Bowers Ave, Santa Clara, CA 95051. Phone (408) 727-0700. **Circle No** 180

LINEAR SUPPLIES. Q Series UL-recognized open-frame devices furnish output voltages of 5, 12, 15 or 24V dc and output currents of 1.2 to 12A for 5V models, 1.2 to 4.8A for 24V versions. Overvoltage protection is standard on all 5V outputs and optional for the others. Dual- and triple-output models are also available. All units incorporate a grounded shield for 2500V isolation between the primary and secondary windings, and outputs supply either positive or negative voltages. Other features include 115/230V ac inputs, full-output ratings over 0 to 50°C, short-circuit and overcurrent protection and terminals for remote-sensing leads. Line regulation specs at $<\pm0.05\%$ for 10% line change; load regulation, $<\pm0.05\%$ for 50% load change. $25.70 to $89.55 for 5V single-output models with overvoltage protection; $25.70 to $83.95 for 12, 15 or 25V versions without OVP. **Dynage Inc,** 1331 Blue Hills Ave, Bloomfield, CT 06002. Phone (203) 243-0315.

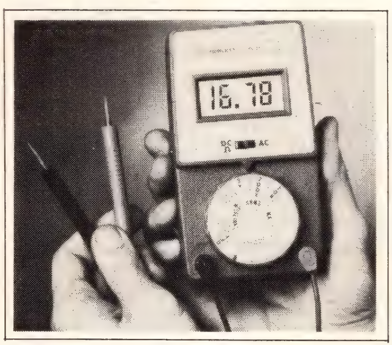
Circle No 181



New Products



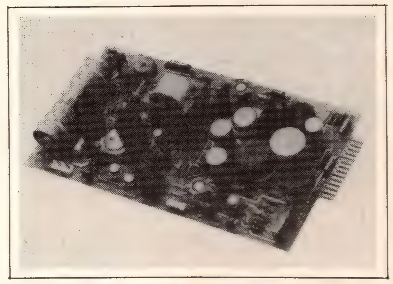
SWITCHER. An addition to the Ugly line, the ES130 Series furnishes a main output of 5V/20A and auxiliary outputs of ±12V/1.5A, ±15V/1.2A and 5V/0.5A. Overvoltage protection is standard on the main output and optional on the others. You can select inputs from 90 to 125 or 180 to 250V, 47 to 63 Hz. Other features of the 10.76×5.25×2.375-in. supply include tight regulation, low noise, convection cooling without additional heat sinking and full rating to 40°C. Open configuration, $182; enclosed, $189 (250). **Elpac Power Systems,** 3131 S Standard Ave, Santa Ana, CA 92705. Phone (714) 979-4440. TWX 910-595-1513.
Circle No 182



DIGITAL VOM. A 6-function, 24-range unit, Model 3410 features a 1000V ac/dc range, overload protection to 600V on all current ranges (with 2A/250V and 3A/600V fuses), protection to 1000V on resistance and voltage ranges and typical 9V-alkaline-battery life of 500 hrs. Its 3½-digit, 0.5-in.-high LCD has overrange blanking indication plus autopolarity and autozero capability. The unit comes with 36-in. test leads, screw-on insulated alligator clips, 9V battery, spare 2A fuse, wire tilt stand and instruction manual. Model 3410 kit adds a clamp-on ac ammeter, line separator, 6-kV ac and dc high-voltage probe and carrying case. $140; $208 kit (including VOM). **Triplett Corp,** 1 Triplett Dr, Bluffton, OH 45817. Phone (419) 358-5015. TWX 810-490-2400. **Circle No 183**

DEVELOPMENT SYSTEM. The microprogramming Model DS500 features a 4-MHz Z80-based computer system with 64k bytes of memory, two dual-density floppy-disk drives and a CRT terminal. A 2901-based PROM emulator/logic-state analyzer ties to the computer as well as the CRT terminal. The logic-state analyzer furnishes a 20-MHz trace (1023 words deep), expandable to 80 channels wide. An unlimited break/trigger feature provides simultaneous and independent arming, conditional break/trigger and unconditional break/trigger of any number of addresses within the 8192-location addressing space. Two external-event break/trigger inputs can capture glitches as short as 8 nsec. Other features include single-step capability and PROM-emulator output enable/disable. From $15,900. **Hilevel Technology Inc,** 14661C Myford Rd, Tustin, CA 92680. Phone (714) 731-9477.
Circle No 184

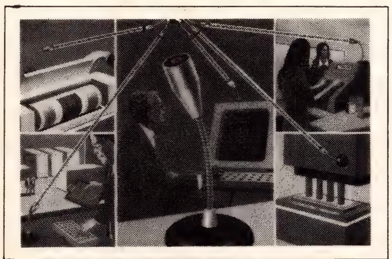
SWITCHER. An open-frame 50 to 65W unit furnished in pc-board form, the 5×9-in. Etatech Series provides as many as five outputs. The primary output is rated at 5V to 8A; the others at ±12 to ±15V to 12W, −12 to −15V to 12W and 5 to 15V (either polarity) to 18W.



Input-voltage range specs at 85 to 135V rms, 47 to 440 Hz single-phase or 115 to 185V dc. Regulation on primary output equals ±15 mV (line) and 10 mV (load), 10% to full load. Total line, load and interaction regulation (secondary outputs) equals ±10%. Ripple and noise on the primary output are held to 100 mV p-p; on the secondary outputs, 2% or 200 mV p-p. Short-circuit and overload protection come standard. $132.20 (100). **Adtech Power Inc,** 1621 S Sinclair St, Anaheim, CA 92806. Phone (714) 634-9211.
Circle No 185

DATA-ACQUISITION SYSTEM. Storing 600M bits on an ANSI-compatible ¼-in. tape cartridge, this system operates with dual µPs to selectively receive, format, record and reproduce data from as many as four 0 to 200k-bps serial-asynchronous data channels. It records for nearly 1 hr at 200k bps and for more than 6 days at an input rate of 1000 bps. Data bursts of 128k bits can be accommodated at megabit rates. Recording format is 7200 bpi; data records in serpentine fashion on 10 tracks. Total tape length equals 700 ft. The tape drive uses a 10,000-hr brushless dc motor with a proprietary digital servo. $16,000 to $29,000. Delivery, 6 months ARO. **Peripherals Development Associates Inc,** 3303-B1 Harbor Blvd, Costa Mesa, CA 92626. Phone (714) 546-9640.
Circle No 186

COMPONENTS & PACKAGING



DATACOMM NETWORK. Model 6010 Datanet can replace fiber-optic or hardwired data links, telephone lines and modems connecting terminals, process-control transducers, computers and controllers.

All solid state (including light sources), the optical system uses infrared energy to transmit serial binary data over line-of-sight paths. The receiver circuitry compensates for changes in atmospheric conditions such as fog, dust, strong sunlight or smoke, allowing system use outdoors or in harsh industrial environments.

All full-duplex channels are operable simultaneously at 0 to 2400, 4800 and 9600 bps without requiring user adjustment, and the remote transceiver station can be placed as far as 35 ft from the central transceiver (up to 328 ft with Model 5010 transceiver).

Plug compatible with most μCs and peripherals, the system comes with standard RS-232 or current-loop interfaces; others are available. $2750 for 5-channel system. **Scientific Radiation Corp,** 1201 San Antonio Rd, Mt View, CA 94043. Phone (415) 965-0910. TLX 345506. **Circle No 225**

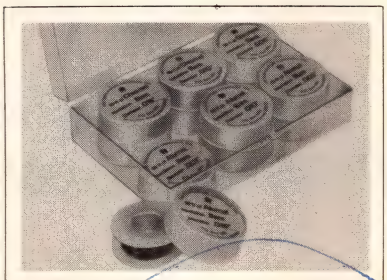
COMPUTER CHASSIS. Packaging disk-based-computer and μP systems, the rack-mountable Model Q MFR-1 can house nine pc-board or Scotchflex-type wiring modules, one or two 5.25-in. floppy-disk drives, a linear or switching power supply and ac line filtering. The 10.5×19-in. unit can be remotely turned on and off via a solid-state relay for use with modems or multiple-processor networks and accommodates pc cards on 0.1-in. centers with dual 40-pin card-edge connectors. The enclosure is constructed of black anodized aluminum with extruded cross members. $250 to $500, depending on options. **Q Computers,** 134 Water St, Wakefield, MA 01880. Phone (617) 245-7323. **Circle No 226**

New Products

F-O RCVRS, XTMRS. Epoxy encapsulated in SMA-type brass connectors, these units mate with any SMA-terminated fiber-optic system. Model 9824.01.A is a silicon-phototransistor receiver; Model 9824.02.A, a silicon PIN-photodiode unit with a rise time of 25 nsec. Models 9823.01.A and 9823.02.A IR LED transmitters operate at 940 nm, while Model 9823.03.A produces an 890-nm output. The units operate between −55 and +100°C. Model 9824.01A, <$14; Model 9824.02.A, approximately $40; Model 9823.01.A, $20; Model 9823.02.A, $30; Model 9823.03.A, $22 (100). **Opti-Cal Inc,** Box 10362, Glendale, CA 91209. Phone (213) 246-3901. **Circle No 227**

PRESSURE TRANSDUCER. A general-purpose unit packaged in a stainless-steel diaphragm and case, Model AB measures from 0 to 6 and 0 to 20,000 psi and comes in gauge, absolute and sealed versions. Suiting industrial, oil-drilling, oceanographic, medical, aerospace and process-control applications, it features accuracy to 0.5% (including nonlinearity, repeatability and hysteresis). Output equals 100 mV at rated pressure. $100 (100). **Data Instruments Inc,** 4 Hartwell Pl, Lexington, MA 02173. Phone (617) 861-7450. TWX 710-326-0672. **Circle No 228**

LED STICK DISPLAY. The multidigit 0.3-in.-high MMN-30000 Series display uses a GaAsP-on-GaP-substrate die, comes in 2- and 4-digit end-stackable packages and provides orange, yellow, green and high-efficiency-red outputs, prematched for brightness and hue. Lens-color options can tailor the display to a particular application. Viewable in sunlight under normal conditions, it operates over −40°C to +85°C and comes in multiplexed or direct-drive configurations. $2.75 for 2-digit unit (1000); $5.60 for 4-digit version (500). **General Instrument Corp,** 3400 Hillview Ave, Palo Alto, CA 94304. Phone (415) 493-0400. **Circle No 229**



THERMOCOUPLE WIRE. Containing 12 spools of calibrated thermocouple wire, these kits can be used to form thermocouples that meet the ANSI Limits of Error for Thermocouples standard (MC96.1, 1975) if produced using standard manufacturing practices. Four kits are available: Kit E, Chromel and Constantan; Kit J, iron and Constantan; Kit K, Chromel and alumel; and Kit T, copper and Constantan. You get six wire sizes in each kit, ranging from 0.001 to 0.015 in. in diameter. Each spool contains 50 ft of wire, protected with snap-on covers. $89. **Temperature Co Inc,** Box 686, Metuchen, NJ 08840. Phone (201) 287-3490. **Circle No 230**

SOCKET STRIPS. Providing a double row of contacts on a 0.1-in. grid, Socket Strips have terminals of one row bused to terminals of the other row to provide a commoned 1-row pinout. The terminals can also be left unbused for use as an LED-array socket. You can connect any number of strips side by side, maintaining the 0.1-in. grid pattern. Both square-wrap and solder-pin terminals are standard in tin or gold plate. Solder-pin styles plug into themselves, permitting stacking for breadboarding or vertical packaging. $1.45 (100) for a 16-contact commoned 2-row assembly. **Samtec Inc,** 810 Progress Blvd, New Albany, IN 47150. Phone (812) 944-6733. **Circle No 231**

OPTICAL FIBER. For short-to-intermediate-distance and medium-bandwidth applications, this moderate-loss fiber consists of a silica core, plastic optical cladding and a protective jacket. It comes in standard diameters of 200, 300, 400 and 600 μm; other sizes are also available. Attenuation specs at <50 dB/km at 790 nm. Features include NA of 0.3, a 1.46 core index of refraction, 20-MHz-km bandwidth, short-gauge-length tensile strength >60 kg/mm^2 and claimed low radiation sensitivity. From $0.50 per metre (small qty) for 200-μm-core fiber. **EOTec Corp,** 200 Frontage Rd, West Haven, CT 06516. Phone (203) 934-7961. **Circle No 232**

ISOLATOR. Model 60A2051 covers a frequency range of 8 to 18 GHz and, excluding connectors and termination, occupies only 0.125 in.^{3} 16-dB min isolation is guaranteed, as are 0.7-dB max insertion loss and 1.5 max VSWR over −45 to +85°C. Designed for airborne and missile environments, the unit sports SMA female connectors. $138 (small qty). **Trak Microwave Corp,** 4726 Eisenhower Blvd, Tampa, FL 33614. Phone (813) 884-1411. TLX 52827. **Circle No 233**

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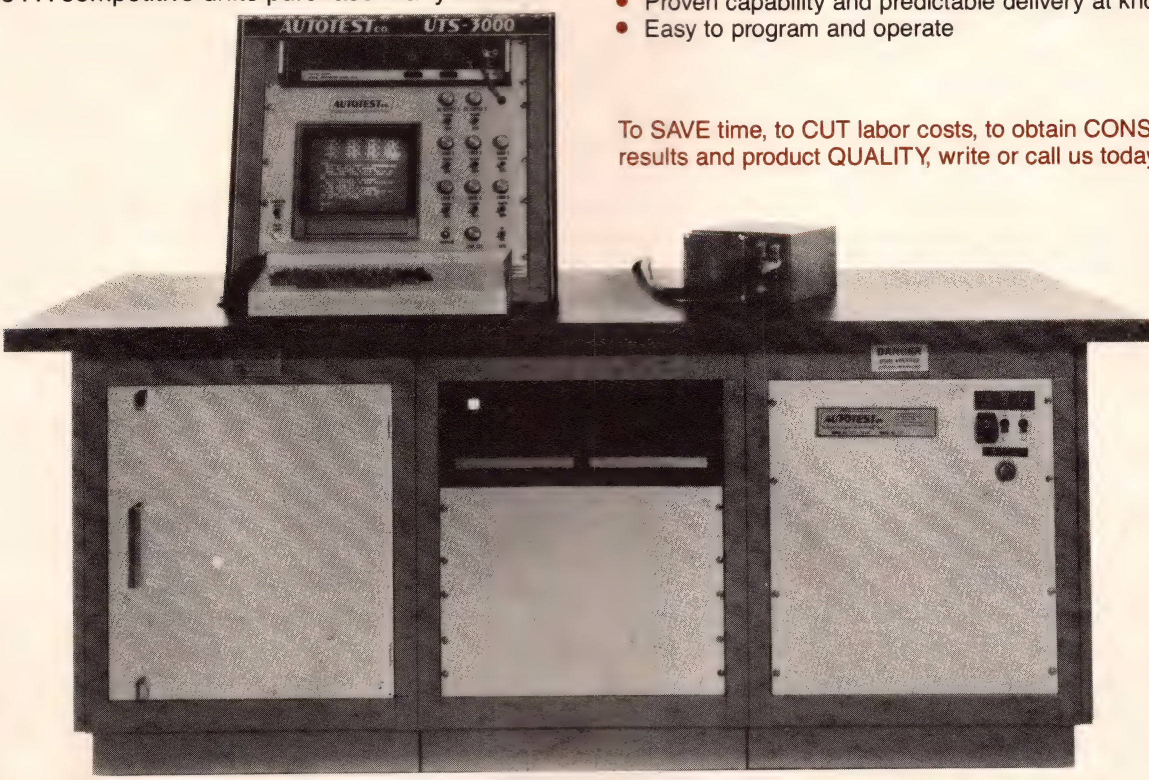

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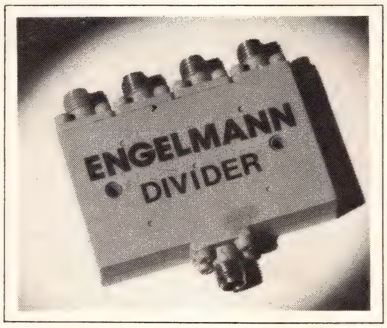
For more information, Circle No 92

New Products

LARGE-AREA LCDs. Standard Model 740 (6-digit) and 742 (8-digit) displays feature bonded pin connectors. Both offer 0.5-in. character heights and include colons and decimal points. The displays operate over a 3 to 20V rms range and furnish low dissipation (50 μW typ for Model 740). Package sizes measure 2.75×1.2 and 3.7×1.2 in. for the 740 and 742, respectively. Connectorless versions are optional. **Beckman Instruments Inc,** Box 3579, Scottsdale, AZ 85257. Phone (602) 947-8371. **Circle No** 248

WIRE-WRAPPING BOARDS. Model 2-8010 comes in two connector configurations (-A, with 296 I/O locations; -B, with 272 I/O pins) for direct installation into the SBC 80/10 card cage. Both feature a universal-style pattern with 62 rows of 52 plated-through holes on 0.1-in. centers. The boards accommodate DIP-pin spacings of 0.3 to 0.9 in. Bypass capability is provided for all independent planes, and power, ground and I/O locations come prepinned. $93.50 for 2-8010A version. **Hybricon Corp,** 410 Great Rd, Littleton, MA 01460. Phone (617) 486-3174. **Circle No** 234

PROCESS METER. The CM-35X requires no external supply, drawing its operating power directly from a 4- to 20- or 10- to 50-mA current loop. You can scale the 3½-digit device to display data in almost any engineering unit. The 0.48-in. LCD provides a user-selectable trailing zero or a choice of °F or °C descriptors. You can also access other segments of the inactive last digit to display A, E, N or 1. Stackable cases are available (no extra charge) for multiple-meter-array applications. $75. **Texmate Inc,** 348 S Cedros Ave, Solana Beach, CA 92075. Phone (714) 481-7177. **Circle No** 235



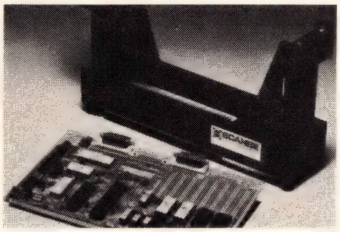
DIVIDER/COMBINER. Model D412M resistor-isolated power divider operates over 8 to 18 GHz with minimum isolation of 18 dB. Insertion loss equals 1 dB max, insertion phase is within ±5° port to port and amplitude balance is within ±0.2 dB. In power-divider mode, input VSWR measures 1.7 max. In 4-way power-combiner usage, input VSWR to each port equals 1.5 max. Internal resistors have a power rating of 0.25W cw, 1 kW pk. $175. Delivery, 60 days ARO. **Engelmann Microwave Co,** Skyline Dr, Montville, NJ 07045. Phone (201) 334-5700. **Circle No** 236

DIP DELAY LINES. DP14 Series units are available in MIL and commercial versions, both TTL compatible. They are fully encapsulated and come with delay ranges of 10 to 1000 nsec, delay/rise-time ratios of 5:1 and impedances of 50 to 500Ω. Taps are spaced at 10% intervals, and package heights of 0.187, 0.225 and 0.3 in. are available. Operating range spans −30 to +85°C for commercial versions. Approximately $5 and $6 (1000) for commercial and MIL units, respectively. Delivery, 10 to 12 wks ARO. **Kappa Networks Inc,** 165 Roosevelt Ave, Carteret, NJ 07008. Phone (201) 541-1600. **Circle No** 237

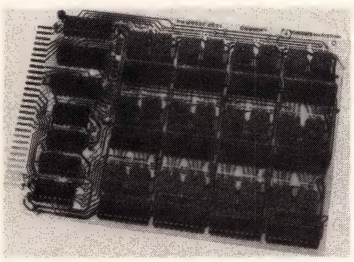
ISOLATOR CARD. In the presence of 250V common-mode voltages, Model 722 analog-to-analog isolator handles inputs of 25 mV to 100V dc in four ranges with continuous zero and span (gain) adjustments. It provides either a process-current (4 to 20 mA) or dc-voltage (1 to 5, 0 to 1, 0 to 5 or 0 to 10V dc) output. The Span pot has a 10:1 adjustment range, and the Zero pot adjusts from 0 to 25% of maximum input span. Two response options are available: dc to 10 and dc to 100 Hz. From $160. Delivery, 6 wks ARO. **Acromag Inc,** 30765 Wixom Rd, Wixom, MI 48096. Phone (313) 624-1541. **Circle No** 238

PRESSURE TRANSDUCERS. Models 204 and 204E feature 5V outputs, <1 msec response, 0.02% repeatability, 0.05% hysteresis and 0.1% nonlinearity. In addition, they have full-scale gauge and absolute pressure ranges of 25 to 10,000 psi and 0 to 14.7 psi vacuum, 10Ω output impedance and 0.01% max output noise. Model 204 is compensated for both zero and sensitivity shifts arising from temperature variations. Model 204E, from $320; Model 204, from $505. **Setra Systems Inc,** 1 Strathmore Rd, Natick, MA 01760. Phone (617) 655-4645. **Circle No** 239

New Products



CARD FILE. The Micro-File features standard 4-connector backplanes, with all interconnections, ready to go in Multibus systems. It includes aluminum end plates and mounting bars and nylon self-lubricating guides that ease card insertion. Standard files have a 4-card add-on capability; custom units are available with variable card counts and spacings. $187 for a typical unit. Delivery, 8 to 10 wks ARO. **Scanbe Div/Zero Corp,** 3445 Fletcher Ave, El Monte, CA 91731. Phone (213) 579-2300. **Circle No 240**



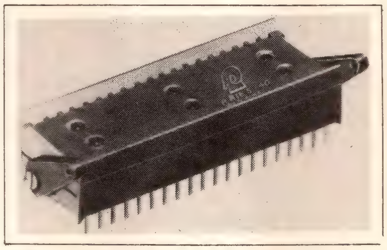
SWITCH CARD. The CS8901 BCD switch panel provides an array of 24 rotary switches (rated for 10,000 detent operations) on a STD Bus-compatible card. Rotors are slotted to permit digit-value selection with a small screwdriver. The card functions like a 12-byte ROM: Each of the 12 address codes selects a pair of digits for reading by the system processor. The -8901 can be I/O mapped via jumpers (with 8-bit addressing) or memory mapped (with full 16-bit addressing). $275 (10). **Circuits & Systems Inc,** 2 Main St, Hollis, NH 03049. Phone (603) 465-7063. **Circle No 241**

New Products

THERMOMETERS. This line of panel-mounting thermometers includes Type J and K thermocouple designs (TC-7200) as well as RTD (PT-7600) devices. TC-7200 units have 1° resolution and operate over −180 to +760°C (J) or −50 to +1250°C (K). An optional LED provides °C or °F readout. PT-7600 thermometers work with DIN 100Ω sensors and offer ranges of −200 to +800°C (1° resolution) or −199.9 to +199.9°C with 0.1° resolution. Readout is in either °C or °F (switch selectable), and both 3- and 4-wire sensor connections are accommodated. TC-7200, $225; PT-7600, $245. Delivery, stock to 60 days ARO. **Caspar Integrated Systems,** 541 S Franklin St, Ft Bragg, CA 95437. Phone (707) 964-4109. **Circle No 242**

FET AMPLIFIER. Model QCL-5009 operates over 5450 to 5828 MHz and employs three GaAs FETs to achieve 20- to 25-dB gain. Over 0 to 60°C, maximum noise figure equals 3.3 dB. Gain flatness specs at ±0.5 dB, and input/output VSWR equals 1.35 max. An integral bias regulator is provided, as are input and output isolators to improve matching. The unit measures 3×2×0.76 in. $1400 (medium to OEM qty). **Raytheon Co,** 130 Second Ave, Waltham, MA 02154. Phone (617) 899-8400. **Circle No 243**

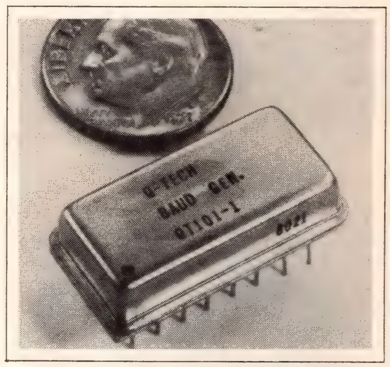
ZIF SOCKETS. These zero-insertion-force DIP sockets are availble in 24-, 28- and 40-pin designs with 0.6-in. centers and with 64 pins on 0.9-in. centers. The normally open contacts are closed with a cam: The last 15° of cam movement provides a wiping action to remove contami-



nation from IC legs. The beryllium-copper contacts are available tin or gold plated. Bodies are 30% glass-filled thermoplastic. Socket height measures 0.45 in. $2.50 to $8. **Aries Electronics Inc,** Box 130, Frenchtown, NJ 08825. Phone (201) 996-684l. **Circle No 244**

IR - EMITTING DIODES. MLED93/94/95 Series GaAs units produce a 3- to 7-mW typ infrared output at 9300Å (typ) with a 100-mA input. V_R equals 6V, I_F specs at 100 mA, and total power dissipation at T_A=25°C equals 215 mW. The Unibloc TO-92 plastic package facilitates mounting and is compatible with automatic insertion equipment. Suiting industrial processing and control applications such as light modulators, shaft or position encoders, end-of-tape detectors and optical couplers, the diodes, because of their light-dispersion angle, also find use in remote-control TV applications. $0.47 (3-mW output) to $0.59 (100) (7 mW). **Motorola Semiconductor Products Inc,** Box 20912, Phoenix, AZ 85036. Phone (602) 244-4556. **Circle No 245**

DELAY LINES. Units in this family of wide-bandwidth, low-insertion-loss ultrasonic devices have nominal frequencies ranging from 3.58 to 28.636 MHz. Furnishing delays in the 63- to 128-μsec range, each delay line consists of two proprietary piezoelectric ceramic transducers and a zero-TC glass plate. As an input electrical signal is applied to the input transducer, its electrical energy is converted into acoustical form. After traveling through the glass plate, it is then converted by the output transducer into an electrical signal with appropriate phase delay. All devices feature approximately 10-dB typ insertion loss, small size (some low-profile units are 0.5 in. high) and −10 to +60°C operating-temperature range. $1.50 to $2.50 (OEM qty). Delivery, stock to 12 wks ARO. **Panasonic Co,** 1 Panasonic Way, Secaucus, NJ 07094. Phone (201) 348-7282. **Circle No 246**



BAUD-RATE GENERATOR. Controlled by a crystal oscillator and suiting modem and data-transmission UART applications, Model QT 101 provides 13 widely used bit rates between 50 and 9600 baud and can control as many as eight transmission channels. Applying the appropriate logic-level signal to the four Rate Select inputs determines its output baud rate. The unit is fully compatible with MIL-spec environmental requirements, and you can specify frequency tolerance to ±0.01% over 0 to 70°C and to ±0.005% over −55 to +125°C. From $24.19 (100) for ±0.01%, 0 to 70°C units. Delivery, 12 wks ARO. **Q-Tech Corp,** 2201 Carmelina Ave, Los Angeles, CA 90064. Phone (213) 820-4921. **Circle No 247**

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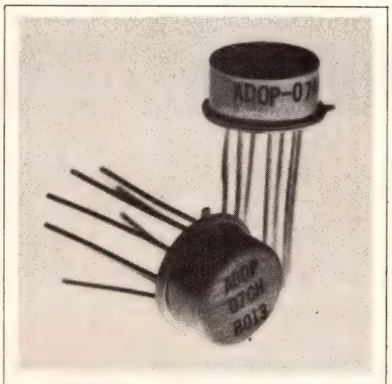


HIGH-GAIN OP AMP. This high-gain version of the standard OP-07 combines a stable offset voltage (as low as 25 μV max) with an input bias current as low as 2 nA max. Internal frequency compensation and input/output protection eliminate the need for additional components.

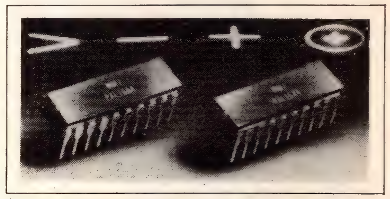
The -A version's 3,000,000 (min) open-loop voltage gain is 10 times higher than the standard OP-07's. High input impedance (to 80 MΩ differential and 200 GΩ common mode), a common-mode input-voltage range of $\pm$13.0V min and CMR to 110 dB min fit the unit for noninverting- and differential-amplifier applications.

Five grades are available. The -07A and -07 versions guarantee initial input offset voltages of 25 and 75 μV max, respectively, and input offset-voltage drifts of 0.6 and 1.3 μV/°C max over -55 to $+125$°C. For the E, C, and D grades, the maximum initial input offset-voltage specs are 75, 150 and 150 μV, respectively. Input offset-voltage drift is pegged at 1.3, 1.8 and 2.5 μV/°C max, respectively, over 0 to 70°C.

Long-term stability is guaranteed to as low as 1 μV/month max. AD OP-07D, $4.55 (100). **Analog Devices Semiconductor,** 804 Woburn St, Wilmington, MA 01887. Phone (617) 935-5565. **Circle No 211**

EAROM. A 256-bit (64×64) nonvolatile device, Model MN9210 utilizes NOVOL logic and MNOS technology to guarantee 1 yr of data retention in the absence of applied power if temperature is maintained within -40 to $+70$°C. Additionally, any word can be programmed independently without disturbing the rest of stored data and without removing the circuit. Housed in an 18-pin DIP, the TTL- and CMOS-compatible unit provides latching data and address inputs, 3-state outputs on the data lines, six address inputs, four data I/O lines, a read/write control line, a strobe-control line, two chip-select-control lines, three power-supply pins and an external capacitor connection. $28.69 (100). **Plessey Semiconductors,** 164 Kaiser Ave, Irvine, CA 92714. Phone (714) 540-9979. **Circle No 212**

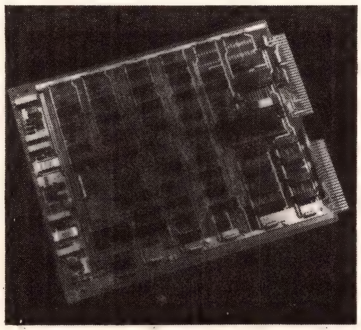
PHASE-CONTROL SCR. A phase-control thyristor that can handle up to 3500V and provide current ratings of 800 to 1200A, Model T9GO minimizes the need for series design in high-voltage circuits. Developed for motor and phase controls, VAR systems, power supplies and fusion systems, it provides guaranteed dv/dt of 300V/μsec. Forward voltage drop specs at 1.7V for the 1200A unit. Other features include gate current of 200A with soft gate control, 0.023°C/W junction-to-case thermal impedance and surge-current capability to 27,000A. The device's power disk package allows for single- or double-sided cooling. The unit can be matched for series or parallel operation, and it's available with factory-assembled air- or water-cooled heat exchangers. $540 (100) for 3500V, 800A unit. Delivery, 10 to 12 wks ARO. **Westinghouse Electric Corp,** Youngwood, PA 15697. Phone (412) 925-7272. **Circle No 213**



PAL DEVICES. Additions to the company's programmable-array-logic Series 20 family, PAL16X4 and -16A4 can perform arithmetic functions such as addition, subtraction, greater than, less than, between limits and equality. Exclusive-OR gates and gated feedback allow the devices to perform counting and logic functions without consuming an excessive number of product terms. The dedicated-parallel-carry feature in the -16A4 permits parallel addition and subtraction. Suiting implementation of 4-bit up/down counters with shift, program counters and between-limits comparators, the units can be programmed on conventional PROM programmers. Propagation delay time equals 40 nsec max, specified over the voltage and temperature range. Clocked-to-output delay time equals 25 nsec. $39 (100). **Monolithic Memories Inc,** 1165 E Arques Ave, Sunnyvale, CA 94086. Phone (408) 739-3535. TWX 910-339-9229. **Circle No 214**

New Products

COMPUTER-SYSTEM SUBASSEMBLIES



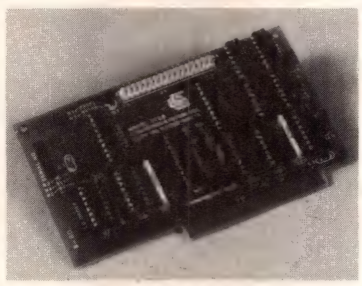
PERIPHERAL BOARDS. Compatible with the Micronova board-computer (MBC) line and the MP/100 and -200 μCs, these boards include an analog and digital I/O interface, a video interface, a RAM/EPROM board and an I/O CMOS memory board.

Model 4335-S analog and digital I/O interface board joins with the company's MBC/2 or MBC/3 to form a 2-board intelligent instrument system utilizing FORTRAN or PASCAL and providing the same computing power as a full Nova computer under the MP/OS operating system. It furnishes 16 I/O lines with handshaking signals and operates under programmed-I/O control. The analog input port includes four single-ended channels and four on-board test channels that measure analog signals with 10-bit resolution. One channel of analog output is also provided.

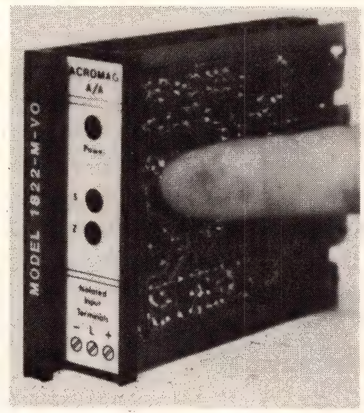
Model 4337-S video interface generates upper- and lowercase alphanumerics on a video monitor and links to an ASCII keyboard.

Extending PROMable capabilities to the MP/200, the RAM/EPROM board comes with 8k bytes of RAM and 32k bytes of EPROM (Model 8688) or with 32k bytes of RAM and 32k bytes of EPROM (Model 8689).

Model 8316 I/O CMOS portable memory board furnishes as much as 16k bytes of nonvolatile memory. Model 4335-S, $800; Model 4337-S, $750; Model 8688, $630; Model 8689, $1260; Model 8316, $800 (4k bytes) to $1900 (16k bytes). Delivery, 90 days ARO. **Data General Corp,** Rte 9, Westboro, MA 01581. Phone (617) 366-8911. **Circle No 215**



PRINTER INTERFACE. Interfacing Apple II computers to a variety of printers using Centronics-type parallel interfaces, including the Okidata Microline 80, the Microtek MT-80P and the Micro Peripherals 88T, Model 7778 has an on-board 256-byte ROM that provides driver firmware and controls ASCII-character output to the printer. The driver responds to standard Apple II printer commands for selection of commmand characters, number of characters per line, auto feed and video echo. A ROM/RAM jumper allows ROM replacement by RAM. Residing in any Apple II peripheral, the board supports the interrupt daisy chain with arbitration logic (including jumper-selectable IRQ generation) and provides DMA daisy-chain pass-through. An 8-bit data-output bus, four status inputs, Data Strobe and Acknowledge handshake signals and a Reset signal are also provided. $119.95. **California Computer Systems,** 250 Caribbean Dr, Sunnyvale, CA 94086. Phone (408) 734-5811. TLX 171959. **Circle No 216**

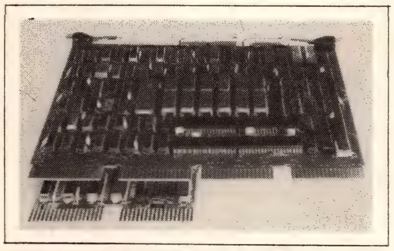


A/A CONVERTERS. Series 1800 analog-to-analog signal-conversion modules, designed for use as the front ends of analog I/O boards, accept real-world inputs and produce high-level single-ended signals for A/D subsystems. Linearization is standard for RTD inputs and optional for thermocouples. Card cages are available in 4-, 8- or 16-model versions with screw terminals for field wiring. All units feature 1500V (breakdown) isolation, 120-dB typ CMR, low-pass-filter options, LED status indicators and 0 to 70°C operation. From $135. Delivery, 8 wks ARO. **Acromag,** 30765 Wixom Rd, Wixom, MI 48096. Phone (313) 624-1541. TLX 230505. **Circle No 217**

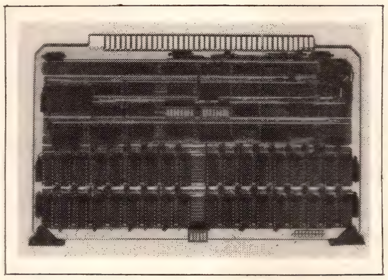
MEASUREMENT / CONTROL CARDS. For applications such as batch processing and equipment control with HP 1000 L Series μCs, L Series measurement and control cards are programmable either in the HP 1000 real-time executive operating system or via assembly language. A high-level analog-input card features an 8-channel differential input (expandable to 40 channels) capable of as many as 55,000 readings/sec with 12-bit resolution. Solid-state differential multiplexers permit data acquisition using four programmable

New Products

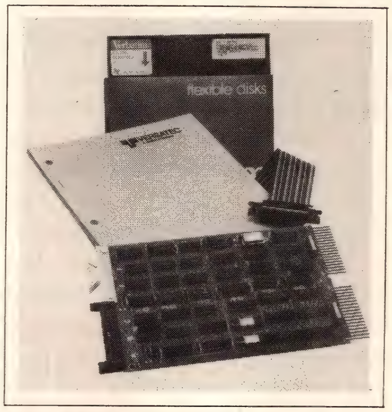
full-scale ranges from ±1.28 to ±10.24V. A digital-input card provides 16 fully isolated inputs with resistor-programmable threshold levels, as well as 16 relay outputs (1A at 28V dc or 0.5A at 120V ac). A second digital card furnishes nonisolated 16-bit I/O plus a separate 4-bit control and status register. $600 to $1500. **Hewlett-Packard Co,** 1507 Page Mill Rd, Palo Alto, CA 94304. Phone local office.
Circle No 218



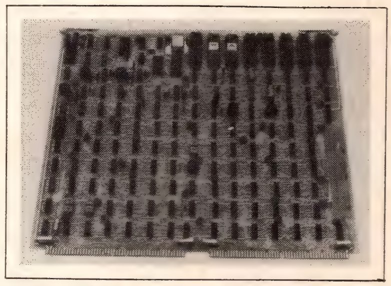
TAPE CONTROLLERS. The T04/T34 family functions with DEC LSI-11 and PDP-11 computers and is TM11/TU10 compatible. Units require one quad board for NRZI mode (PDP-11 or LSI-11); for PE mode, a dual-size PE board is added, drawing 5V and ground from the back panel of the host minicomputer but not using any of the back panel's bus signals. Operating with industry-standard tape drives and providing a 64-byte buffer, the controllers support any combination of 7- or 9-track NRZI or dual-density drives; as many as four drives can be daisy-chained to one controller. 7-track units can operate in NRZI mode at 200, 556 or 800 bpi; 9-track drives, in NRZI mode at 800 bpi or in PE mode at 1600 bpi. Drive speeds to 125 ips are supported. Single-density model, $2600; dual-density version (quad board plus dual board), $3300. **Dataram Corp,** Princeton-Hightstown Rd, Cranbury, NJ 08512. Phone (609) 799-0071.
Circle No 219



RAM BOARD. Available in 16k, 32k, 48k and 64k versions, Model MM-6800D is a 64k×9 module designed for 2-MHz Exorciser I or II operation. It provides even parity with jumper-selectable outputs and two switch-selectable refresh modes for cycle stealing and hidden refresh. Module selection is decoded in 4k-byte increments by setting the lower and upper limits of a DIP switch. With a write-protect switch to safeguard any 8k block or the entire memory, the board uses 5 and 12V supplies and dissipates <7W. $600 for 64k×9 version. **Micro Memory Inc,** 9434 Irondale Ave, Chatsworth, CA 91311. Phone (213) 998-0070.
Circle No 220



PRINTER INTERFACE. Model 125 single-board interface allows DEC LSI-11 systems to use any of the company's electrostatic plotters or printer/plotters, I/O multiplexers, hard-copy controllers or vector-to-raster converters. Plugging into the computer mainframe or I/O expansion chassis and operating under direct program control or DMA, the interface is electrically and mechanically compatible with the PDP-11/03 and -11/23 and the LSI-11/2 and -11/23 systems, and with the LP-11 line-printer drive. Supporting all printer/plotter functions, it permits printing speeds to 1000 lpm and plotting speeds to 34 ft^2/min and can be located as far as 54 ft from the LSI-11. The package includes an RT-11 print/plot driver that allows transfer of print, plot, SPP, remote-function and vector-to-raster-converter data to the unit and a software-test exerciser. Source and object codes are supplied on an RXO1-compatible diskette. $1600. Delivery, 90 days, ARO. **Versatec,** 2805 Bowers Ave, Santa Clara, CA 95051. Phone (408) 988-2800. TWX 910-338-0243.
Circle No 221



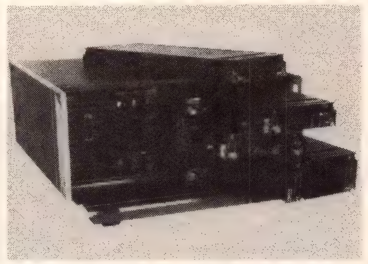
PRINTER CONTROLLER. The μP-based Model VIP-201 plugs into one slot of any Data General minicomputer. Capable of controlling any mix of three Dataproducts- or Centronics-interface-compatible line printers or the 300-lpm Teletype Model 40 printer, it provides driving capability as great as 2000 ft when used with the Model 40 via its SSI interface. Built-in self tests independent of the CPU furnish line-printer-subsystem diagnostics. $2400; 1-printer version, $1900. Delivery, 30 to 60 days ARO. **Vetra Systems Corp,** Box 714, Melville, NY 11746. Phone (516) 454-6469.
Circle No 222

New Products

SYNCHRO CONVERTER. Employing Type II servo loops designed to follow input-shaft velocities as high as 1800°/sec (300 rpm), the 16-bit Model 168H100 synchro- or resolver-to-digital unit provides 1.3′ accuracy over its full temperature range. It maintains this performance despite ±10% signal- and reference-amplitude variations, ±10% power-supply variations, input-shaft velocities to 1800°/sec, as much as 10% harmonic distortion and 40° phase shift between reference and input signals. Inputs are balanced to ±1%, and 60- or 400-Hz operation requires no external transformers. $695 for commercial (0 to 70°C) unit; $795 for military-range (−55 to +105°C) version. **Control Sciences Inc,** 9601-1 Owensmouth Ave, Chatsworth, CA 91311. Phone (213) 709-5510.

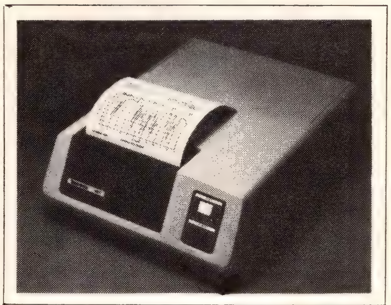
Circle No 223

A/D CONVERTER. For use in automatic test systems, the multiplexing 8-channel Model 8608 can perform as many as 5000 measurements/sec. Resolution equals 12 bits in three bipolar ranges (100 mV, 1 and 10V), and autoranging is provided. Timing capability allows measurements to be taken continuously or on multiple trigger commands. Fully compatible with the IEEE-488 bus, the module can store high-speed readings for later readout and can be programmed to operate in four different modes (single channel, single channel burst, autoscan and autoscan burst). $895. **Jaycor,** Box 370, Del Mar, CA 92014. Phone (714) 453-6580.



Circle No 224

COMPUTERS & PERIPHERALS



HARD-COPY UNITS. Models 4611 (for storage-tube displays) and 4612 (for raster-scan video sources) use a dry carbon toner and an electrostatic process to produce permanent copies on 8½×11-in. dielectric paper. The paper looks and feels like plain bond and permits pen or pencil notations.

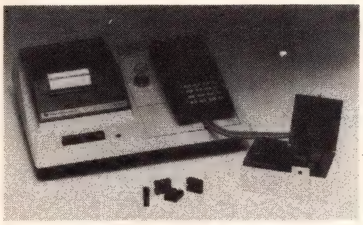
Each roll provides approximately 540 hard copies for approximately $0.02 per sheet and $0.03 per copy (including toner). Both units deliver vertical-format copies in 24 sec; image size is approximately 7½×5¾ in.

Dot density equals 256 dots/in. horizontally, 171 dots/in. vertically. The dots overlap 67% horizontally and 47% vertically.

Options for the 45-lb, 7.135×20.65×16.75-in. units include a 4-channel multiplexer and foreign-operation capabilities. $4400. **Tektronix Inc,** Box 500, Beaverton, OR 97077. Phone (503) 644-0161.

Circle No 187

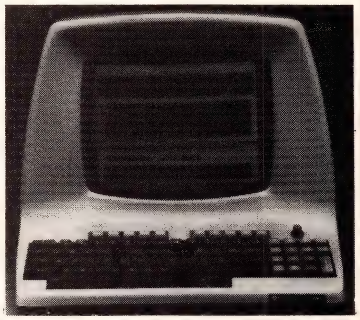
CRT TERMINAL. A block-mode/editing video-display unit, the µP-based Model 550S provides three operating modes for conversational time sharing, transaction processing or text manipulation/software development. Its 24-line screen acts as a movable window accessing 48 80-column lines of memory. In Transaction Processing mode, the optional second page of scrolling memory can store a second page of a form, called up automatically when an operator tabs off the first page. The standard 83-key keyboard includes a multifunction numeric pad and four (shiftable to eight) program-function keys. Also standard is an ASCII serial printer port and an X-On/X-Off host control over terminal block transmissions and field attributes for half-intensity, blink, nondisplay and protected modes. $1189. **Perkin-Elmer Corp,** 360 Rte 206 South, Flanders, NJ 07836. Phone (201) 229-6800. **Circle No 188**



CALCULATOR PERIPHERALS. Interfacing directly to TI-59 and -58 calculators, these module-selector switching devices hold as many as four TI Solid State Software libraries, enabling a user to select and execute any routine in any module without turning off the calculator and removing a library. The manual-selector version features a 4-position switch that can be rotated to select the desired module. Fitting the battery well of the PC-100 printer, the switch can interface to the 59/58/PC-100 combination or to the calculator alone. The automatic-selector model accesses each library under program control. Capable of running a continuous program of up to 20,000 steps, each unit includes four LED lamps that indicate which module is being accessed. Manual selector, $99.95; automatic selector, $199.95. **American Micro Products Inc,** 705 N Bowser, M/S 107, Richardson, TX 75080. Phone (214) 238-1815.

Circle No 189

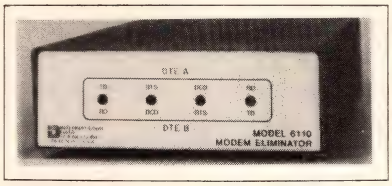
CRT TERMINAL. The ADM-5 Dumb Terminal provides visual attributes such as reverse video, reduced intensity and reverse video/reduced intensity; limited editing capabilities (erase to end of line or page); and a gated extension port for selective



transmission of data to any serial RS-232C peripheral device. It also features a teletypewriter-style keyboard, a built-in numeric keypad, separate cursor-control keys and a full upper- and lower-case 12-in.-diagonal character display with 2-dot descenders as standard. Characters are displayed as a 5×9 dot matrix in a 7×10 dot-matrix field. A Program-mode key permits writing into the display memory as well as the display of

New Products

all control codes. The terminal operates asynchronously in half- or full-duplex modes at any of 11 data rates from 75 to 19.2k bps. $995. **Lear Siegler Inc,** 714 N Brookhurst St, Anaheim, CA 92803. Phone (800) 854-3805; in CA, (714) 774-1010.
Circle No 190



MODEM ELIMINATOR. Permitting the interconnection of data-terminal equipment without modems, Model 6110 can be used in either synchronous or asynchronous mode and with terminals configured for half- or full-duplex operation. Replacing two back-to-back short-range modems, it furnishes internal strap selection of constant or controlled RTS, four selectable RTS/CTS delays, an internal or external clock and nine clock rates ranging from 1200 to 19,200 bps. The DTE interface conforms to RS-232C and CCITT V.24 specifications. Data-terminal equipment can be located as far as 50 ft from the unit (allowing a maximum separation of 100 ft between terminals); a long-distance cable provides maximum separation of 500 ft. $350. Delivery, 60 days ARO. **International Data Sciences Inc,** 7 Wellington Rd, Lincoln, RI 02865. Phone (401) 333-6200. TWX 710-384-1911.
Circle No 191

FORTRAN IV PACKAGE. FORT/LIFT provides major functional extensions to FORTRAN IV. Running on virtually all minicomputers and microprocessors that support FORTRAN, it incorporates FORTRAN-IV-callable subroutines and features character-string and -substring functions, including string comparisons, moves, fills, searches, deletions, insertions and replacements (all functions that operate on variable-length character strings/substrings), plus a disk function that can sort files on up to five variable-length sort keys (numeric or character strings). Universal machine independence is achieved by isolating the few machine-dependent functions into user-supplied primitive routines. $199 on cards or paper or magnetic tape. **Software '70,** Box 3623, Anaheim, CA 92803. Phone (714) 992-2230. **Circle No 192**

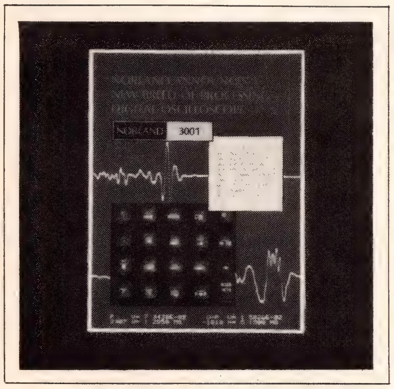
DISK DRIVE. For the company's 6809 Series Chieftain small-business computers, this double-track, double-density, double-sided 5¼-in. flexible-disk drive provides 1.5M bytes of formatted storage capacity in its standard dual-drive configuration. Recording density specs at 5877 bpi, and the unit provides 80 tracks per side, 96 tpi. Track-to track access time equals 3 msec. $4075. **Smoke Signal Broadcasting,** 31336 Via Colinas, Westlake Village, CA 91362. Phone (213) 889-9340. **Circle No 193**

IMPACT PRINTER. Designed to operate with Apple µCs, the IMP2-Apple permits all printer functions to be activated by single commands. Thus, one command can initiate the printing of a screen's contents and control the printing format. Compatible with the PASCAL operating system, the ultralow-profile unit is equipped with both friction and tractor feeds to provide 3-way forms handling:

single sheet, roll paper and fan-fold. It can print 80, 96 or 132 columns of hard copy (throughput, 1 lps). The 7×7 dot matrix furnishes the standard ASCII character set (with special character sets optional), and the printer can handle user-defined as well as high-resolution graphics under software control. $895. **Axiom Corp,** 5932 San Fernando Rd, Glendale, CA 91202. Phone (213) 245-9244. TWX 910-497-2283.
Circle No 194

DISPLAY. Providing 79% more active screen area than standard 80-column displays, the 132-column Model 5210 large-screen unit serves data-processing, text-editing and communications applications. Its 15-in.-diagonal screen displays 33 lines of 132-column text (4356 characters). An optional screen buffer memory stores an additional 33 lines and provides both up and down scrolling. Other features include 96 upper- and lower-case full-sized 5×8 dot-matrix ASCII characters; character highlighting including dual intensity, blink, reverse video and underscore; direct cursor positioning; seven cursor-control functions; 32 graphics characters; and functions for horizontal and vertical forms ruling. The unit's detached typewriter keyboard has a 15-key data-entry pad and 18 function keys; a datacomm interface provides eight switch-selectable speeds from 300 to 38,400 bps. $4500. Delivery, 150 days ARO. **Data General Corp,** Rte 9, Westboro, MA 01581. Phone (617) 366-8911. **Circle No 195**

Literature



Acquiring and displaying waveforms

A 10-pg brochure details the capabilities of Model 3001 processing digital oscilloscope. Claiming that the firm has increased A/D resolution, improved internal and peripheral storage capability, enhanced output annotation and expanded diagnostic capability over an earlier model, it outlines the advantages that processing offers in a digital scope. Finally, it provides specs for the scope's acquisition modes, data memory, frequency response, dc offset and trigger functions. **Norland Corp,** Rte 4, Norland Dr, Ft Atkinson, WI 53538.

Circle No 196

Illustrated data on strain gauges

A guide to the theory and application of strain gauges, a 46-pg handbook details the fundamentals of stress and strain, the relationship between strain and resistance, the Wheatstone Bridge, bridge-sensitivity adjustment and temperature effects. With line drawings, schematics, charts and tables, it provides data on foil strain gauges and gauge-system selection. **BLH Electronics,** 42B Fourth Ave, Waltham, MA 02254.

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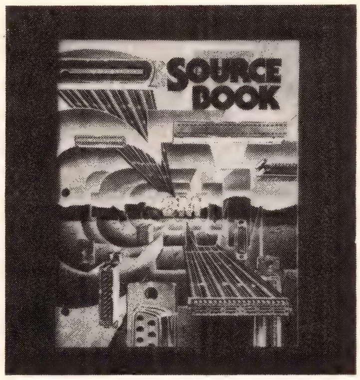


Investigate cable-connector devices

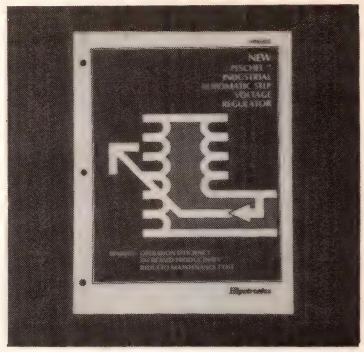
Specs for components in the Scotchflex cable-connector system for mass termination—cable, connectors, assembly equipment and accessories—make up an 85-pg catalog. It describes socket, plug, pc-board, DIP, delta, delta-ribbon and card-edge connectors and headers. A cable/connector mating guide is included. In addition, the catalog outlines the Scotchflex breadboard system, which is claimed to enable a user to go from a finished design to operative prototype in half the time required by standard wire-wrapping or hand-soldering methods. **3M Co,** Box 33600, St Paul, MN 55133. **Circle No** 198

Choose from a variety of filters

Catalog 17F presents a line of custom-built LC filters for frequencies from 20 Hz to 400 MHz. It describes bandpass, band-reject, linear phase, high-pass and low-pass filters and the VCL Series of delay-equalized NTSC low-pass devices for video use. A glossary of filter terms begins the 24-pg brochure. **Allen Avionics Inc,** 224 E 2nd St, Mineola, NY 11501.
Circle No 199

Reference data for the communications industry

The 350-pg "Data Communications Standards Library" describes six EIA RS standards, four EIA industrial bulletins, IBM's Binary Synchronous Communications protocol and ATT's Advanced Communications Service host and terminal functional interface. $85. **Remark International,** 4 Sycamore Dr, Woodbury, NY 11797.
INQUIRE DIRECT



Uses for a step voltage regulator

Highlighting the Peschel industrial automatic step voltage regulator, a 12-pg brochure details its operation, sizes, ratings, response speed and reliability. It also outlines applications for the unit, including magnetic devices, motors, distribution equipment, rectifier loads and resistance heating. A spec table lists data on type of connection, voltage, dimensions and weight for 33 standard models. **Hipotronics Inc,** Drawer A, Brewster, NY 10509.
Circle No 200

Customer evaluations of teleprinters

Providing a summary of user experiences with 10,657 installed teleprinter terminals, a 40-pg report contains specs and prices for 125 teleprinter terminals from 50 vendors. It addresses the pros and cons of using teleprinters vs alphanumeric display terminals, the tradeoffs between impact and nonimpact printers, printer types and trends and the anticipated growth of the teleprinter industry. Survey results include ratings for ease of use, keyboard feel, print quality, hardware reliability, maintenance service and overall satisfaction. $15. **Datapro Research Corp,** 1805 Underwood Blvd, Delran, NJ 08075. **INQUIRE DIRECT**

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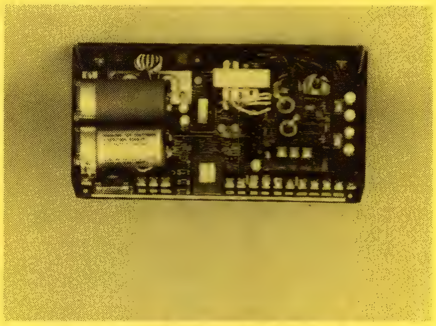

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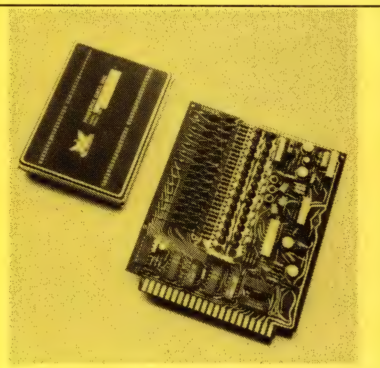
For more information, Circle No 103



ADC 2000/2100 16-BIT A/D CONVERTERS for airborne, other critical applications. Resolution of ADC 2000/2100 series is 1 part in 65,535—16 binary bits or 2's complement; power consumption only 500 mw; accuracy: ±0.004%; linearity: ±0.002%; output control functions CMOS/TTL-LS compatible with any system. Tested, calibrated, system-ready except for power supply. ADC 2000: P.C. Card; ADC 2100: Encased. **PHOENIX DATA, INC.,** 3384 W. Osborn, Phoenix, AZ 85017. PH 602/278-8528.

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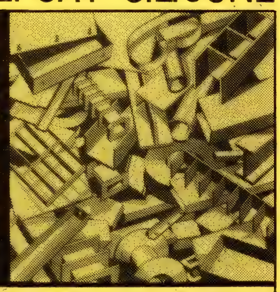

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Literature

Select data-processing supplies and services

"The Easy Reference to Essential Data Processing Supplies" is a guide for specifiers of diskettes, disk packs, printer ribbons, labels, data-processing forms, terminal stands, data workstations, cables and a variety of products and services. It features compatibility charts to match data-access and -processing systems with appropriate products. **American National Supply Corp,** 1243 W 134th St, Gardena, CA 90247.

Circle No 201

Applications data for microcomputer line

This collection of microcomputer literature includes the "PIC Series Microcomputer Data Manual," which describes the family's architecture, instruction set, electrical specs and support hardware and software. Another manual details commonly used software routines, while a third highlights the PIC Field Demo System, a pc module used to demonstrate and test an application program before it's committed to masked ROM. Other brochures outline features of an in-circuit-emulation system and a cross assembler. **Microelectronics Div General Instrument Corp,** 600 W John St, Hicksville, NY 11802.

Circle No 202

Study advanced TRS-80 interfacing techniques

TRS-80 Interfacing—Book 2 introduces advanced interfacing techniques that permit an operator to accomplish real-world tasks with the TRS-80 computer. For example, the 256-pg book details how to drive high-current and high-voltage loads, generate voltage and current signals, measure unknown voltages and currents and use remote-control circuits. It explains how to use the latter circuits to allow the computer to control universal asynchronous receiver/transmitter chips, A/D and D/A converters and other devices located some distance from the unit. Included are complete software examples. $9.95 (softbound). **Howard W Sams and Co Inc,** 4300 W 62 St, Indianapolis, IN 46268.

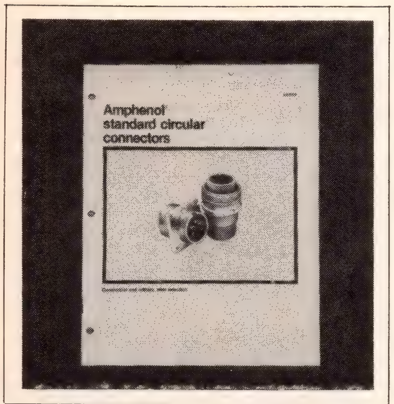
INQUIRE DIRECT

A look at computer storage peripherals

A monthly review of industry and market developments in storage peripherals, "Random Access Int'l" looks at data streaming in its first issue. The newsletter covers rigid- and flexible-disk drives, tape drives and associated magnetic media, component requirements and new storage technologies. $240 annually; $264 outside US. **RAI Publishing Inc,** 4943 Bosworth Ct, Newark, CA 94560.

INQUIRE DIRECT

Literature



Options in choosing circular connectors

A 36-pg catalog features a line of standard circular connectors. The selection guide furnishes data on environmental capabilities, wire gauges, plug and receptacle requirements, shell-type needs (solid or split), socket locations and finish options. A chart summarizes the range of available circular-connector styles—wall, cable and box receptacles, plus straight, quick-disconnect and angle plugs—and cross-references them by insert number. **Amphenol North America,** 2122 York Rd, Oak Brook, IL 60521.

Circle No 203

How to utilize disk- and tape-storage subsystems

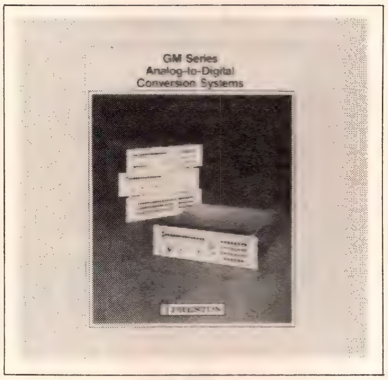
Outlining hardware, software and system considerations for connecting disk- and tape-storage subsystems to DEC computers, the "Peripheral Controller Handbook" includes illustrations and comparison tables. Section I discusses disk controllers and provides data on disk drives and subsystems, hardware design, and microcode implementations, as well as software considerations. Section II describes tape controllers and features device-selection considerations. **Emulex Corp,** 2001 E Deere Ave, Santa Ana, CA 92705.

Circle No 204

Characteristics of manual switches

A 148-pg catalog describes a line of pushbutton, toggle, rotary-selector and interlock switches. Catalog 30's 4-pg selection guide provides panel-area, display, illumination, behind-panel-depth, mounting, termination, sealing, electrical and circuitry data. Mounting drawings, cutaways and expanded views accompany all product descriptions. Dimensions are provided in English and metric equivalents. **Micro Switch,** 11 W Spring St, Freeport, IL 61032.

Circle No 205



Capabilities of A/D-conversion systems

Performance tables in a 28-pg booklet detail overall accuracy and speed of a family of A/D-conversion systems. The brochure also describes the operation of Model GMC Logic Control Systems, which permit both front-panel and computer selection of input channel address and sequence, and includes operational examples of how to program and interconnect those systems. Lastly, it features a computer-interfacing subsystem for use with the Hewlett Packard 93596L interface system and many DEC and Data General Computers. **Preston Scientific Inc,** 805 E Cerritos Ave, Anaheim, CA 92805.

Circle No 206

Literature

Utilizing data-acquisition systems

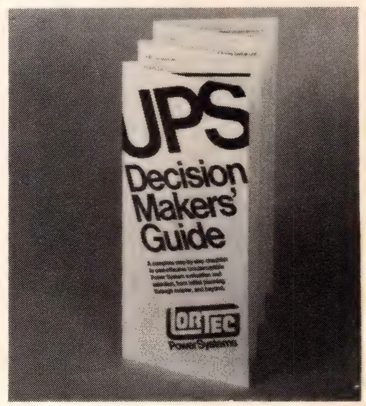
A 12-pg brochure details electrical and mechanical specs for 16- and 8-channel, single-ended, 12-bit-resolution, 72-pin miniature data-acquisition systems, Models MDAS-16 and -8D. Block diagrams and app notes explain the capabilities that suit the modules for use in low-level-signal applications involving bridge amplifiers, transducers, strain gauges and thermocouple interfaces. **Datel-Intersil Inc,** 11 Cabot Blvd, Mansfield, MA 02048.

Circle No 207

Overview of optoelectronic devices

Highlighting a line of LED lamps, displays and optoisolators, a 20-pg catalog suggests applications for the products covered and provides data on color options, including green, yellow, orange, red and high-efficiency red. It lists specs on MAN Series LED displays, showing actual digit size for each product and describing 13 display-package styles. It also pictures package sizes for the LED-lamp series and includes specs for luminous intensity at forward current, maximum power and typical viewing angle. For the optoisolator line, the catalog details device size, output configurations, emitter voltage and the detector's minimum output voltage (BV_{CEO}), presenting three package styles. **Optoelectronics Div General Instrument Corp,** 3400 Hillview Ave, Palo Alto, CA 94304.

Circle No 208



Choosing uninterruptible power systems

A 12-pg foldout brochure features a 173-point checklist for cost-effective uninterruptible-power-system evaluation and selection. It enumerates considerations for performing a cost-justification analysis, determining necessary equipment and system features, evaluating prospective suppliers, properly installing a system and ensuring reliable performance. **Lortec Power Systems Inc,** 5214 Mills Industrial Parkway, North Ridgeville, OH 44035. **Circle No 209**

Programs and publications on computer graphics

A 32-pg catalog describes computer-mapmaking and supplementary programs, cartographic data bases, and related publications. It outlines nine programs related to computer-graphics and geographic-information systems, including KWIC, a bibliographic processing system; GIMMS, a user-oriented thematic mapping system; and MDS(X), a collection of multidimensional scaling algorithms linked under one command language. **Laboratory for Computer Graphics and Spatial Analysis,** Graduate School of Design, Harvard Univ, 520 Gund Hall, Cambridge, MA 02138. **Circle No 210**

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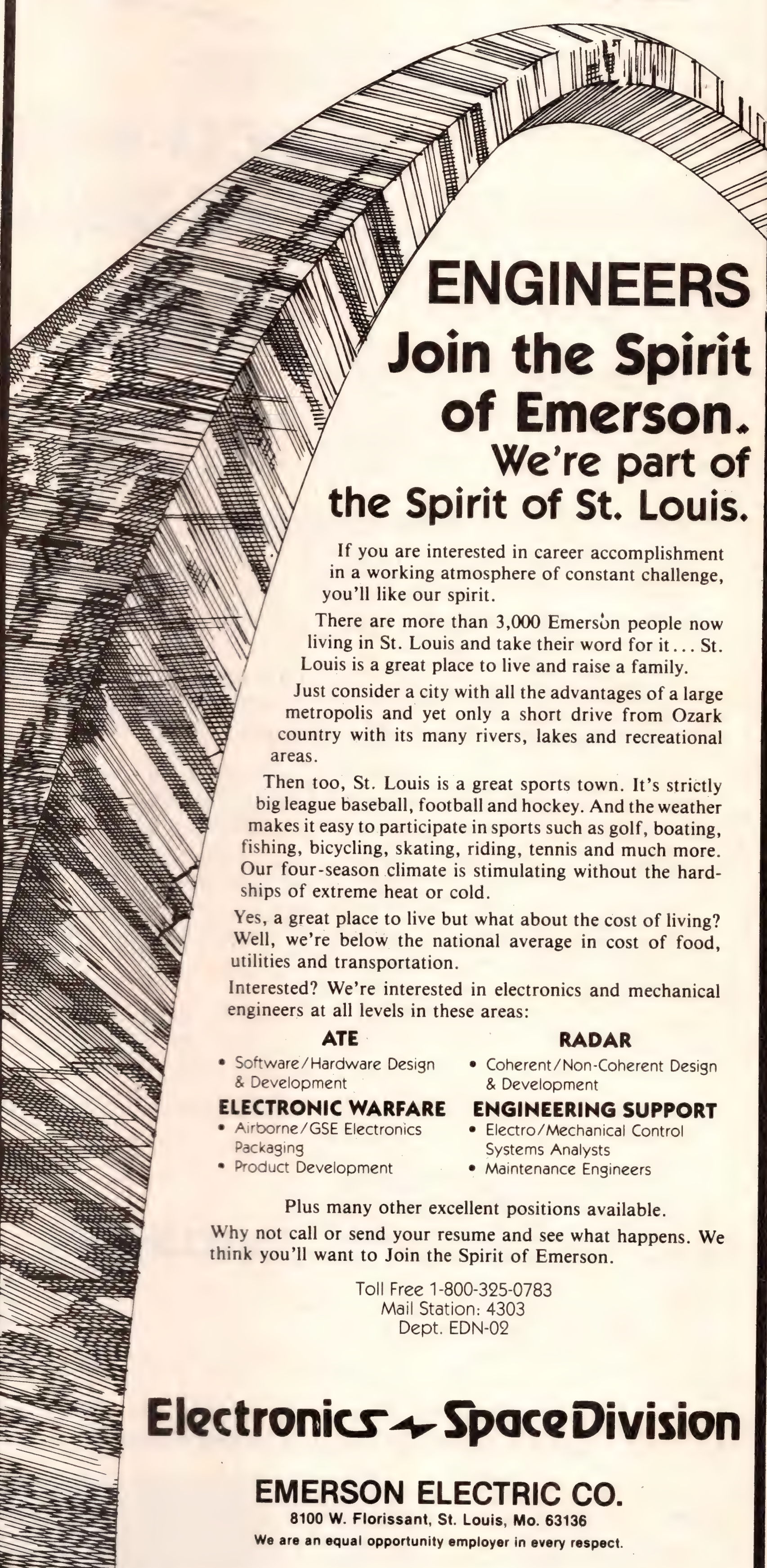

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Looking Ahead: Trends and Forecasts

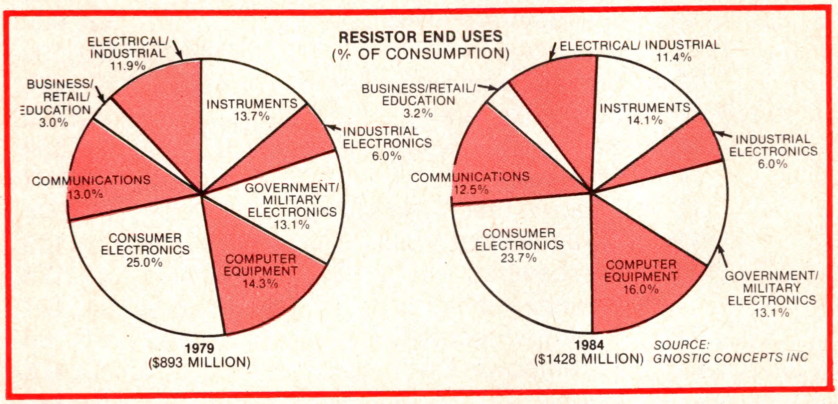
$1.05B resistor market predicted for 1981

Increasing costs, undercapacity, changing technology, overseas competition and recession all contributed to last year's lackluster 7% resistance-product market growth and $956 million in US sales. But the market should do better this year: It's expected to exhibit a 9% growth rate and reach the $1.05 billion mark. And with a predicted 9.8% compound annual growth rate (CAGR) between 1979 and 1984, total US sales should swell to $1.4 billion, according to Gnostic Concepts Inc, Menlo Park, CA.

Spearheading market growth, automotive-industry demand is doubling the overall resistor-market growth rate. Sales to car manufacturers—primarily for engine-performance systems—should increase from approximately $40 million in 1979 to approximately $90 million in 1984.

Resistor networks' performance and package compatibility with ICs will enable them to exhibit an 18% CAGR and capture 18% of the OEM market by 1984. Thick-film technology will dominate, but thin-film devices are also expected to rack up vigorous sales increases.

But although advanced IC technology should boost network sales, it will impede trimmers' market share. Because LSI devices and smart linear ICs permit less precise current control and have higher inherent stability, these devices' increased use should soften trimmer demand.



5.2M desktop computers worldwide by 1984

No longer low-end products geared primarily to the home-computer market, increasingly powerful desktop computers now offer up to 192M bytes of on-line storage, multiuser capabilities and multiple peripherals. Such qualities will help fuel an impressive 972% increase in worldwide installed base, rising from 535,000 units in 1979 to more than 5.2 million machines by the end of 1984. US installed base over the period will jump from 371,000 to approximately 3.1 million units, forecasts International Data Corp (IDC), Waltham, MA.

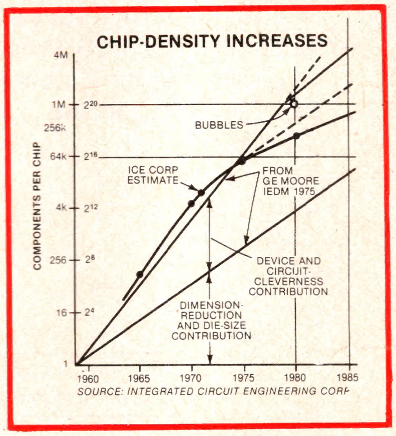
US sales of business/professional systems will show a 52% compound annual growth rate (CAGR) from 1979 to 1984 with approximately 1.7 million installed units by 1984.

Despite healthy growth rates, though, the future isn't all rosy for the desktop-computer industry. Improperly running software (a complaint of many users), an expected absence of dramatic price reductions in the foreseeable future and an industry shakeout by 1983 could create problems for desktop-computer manufacturers.

Chip densities to rise at slower rate

Although the electronics industry has become accustomed since the early '60s to a 16-fold increase IC density every 5 yrs, designers should not expect that rate to continue, warns Integrated Circuit Engineering Corp, Scottsdale, AZ.

Thus, although chip feature- and die-size reductions have kept pace with the 16-fold/5-yr rate, the "circuit-cleverness" contribution to rising chip densities has been leveling off as designers find it increasingly difficult to effectively utilize smaller chip dimensions.



The result? The experience curve will flatten, resulting in less dramatic price reductions.

Material for this page developed from *Electronic Business* magazine and other sources by Jesse Victor, Assistant/New Products Editor, and Joan Morrow, Assistant Editor.

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